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EDITOR'S NOTE: THE 50TH VOLUME OF *THE MICHIGAN BOTANIST*

It is immensely gratifying to inaugurate the fiftieth year of publication of *The Michigan Botanist*! Reaching this milestone acknowledges that the study of botany in the Great Lakes region is alive and well. Although they are too numerous to acknowledge individually, the previous editors, business managers, and volunteers are all thanked for their efforts to ensure that this high-quality publication has persisted.

As would be expected, a few aspects of the journal have changed in the past 49 years; yet, many facets of the publication remain the same. In the first issue of *The Michigan Botanist* published in 1962, the Editorial board wrote: “With this publication, the Michigan Botanical Club launches into a new venture, the final direction of which it would be premature to predict with precision” (*The Michigan Botanist*, volume 1, issue 1, p. 3). Upon comparison of the content of that first issue to those of the last five years, it is clear that the original intention of the journal remains: we continue to publish content devoted to the diverse aspects of plant life including fungi, lichens, algae, non-vascular and vascular plants in the Great Lakes region. Furthermore, on the same page the editors stated: “It may be expected that on conservation issues, *The Michigan Botanist* will reflect the interests of the Michigan Botanical Club”. Without a doubt, the numerous papers published in *The Michigan Botanist* documenting all aspects of the flora of the diverse regions of the Great Lakes have contributed to conservation efforts over the past 49 years. In these ways, it is likely that the direction the journal has taken is similar to that envisioned by the editors in 1962. Yet, on the other hand, in 1962 it would have been impossible to predict that *The Michigan Botanist* could exist in an electronic format and be dispersed to every corner of the globe! Therefore, it is with great pleasure that I inform readers that MPublishing and the Michigan Botanical Club (MBC) announce the launch of an online, open-access component to *The Michigan Botanist*: http://quod.lib.umich.edu/m/mbot. This is the first time the full text of the journal has been made available online. The initial launch consists of volumes 37–48 (1998–2009), with both older and newer issues becoming available in the near future. Dues-paying members of MBC will continue to receive print copies of the journal, but going forward, the full text of each issue will also be made freely available online to search, browse, read, and download.

In closing, it is probably safe to say that *The Michigan Botanist* will continue to publish on all aspects of plant life in the Great Lakes region in order to continue to contribute to conservations efforts. Yet, I will echo the sentiments of the founding editors by stating that it remains impossible to predict what other directions *The Michigan Botanist* will take in the next 50 years.

—Todd J. Barkman

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WETLAND ASSESSMENT AND INVENTORY OF THE POKEGAMA CARNEGIE WETLAND STATE NATURAL AREA, DOUGLAS COUNTY, WISCONSIN

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ABSTRACT

The Pokegama Carnegie Wetland State Natural Area (SNA) is one of 590 properties designated as a state natural area in Wisconsin and has been infrequently studied. The Wisconsin Floristic Quality Assessment (WFQA) and the Wisconsin Wetland Plant Biotic Index (WWPBI), developed by the Wisconsin Department of Natural Resources (WDNR) were used during the assessment of the wetland plant community types found at the Pokegama Carnegie Wetland State Natural Area. The WFQA is a numerical value and was based on species diversity and composition. It was designed to compare the floristic quality between similar sites and for tracking changes at the same site over time. The WWPBI is a multi-metric index based on relative importance values (IV) (percent cover and frequency of occurrence) of nine community attributes based on taxonomic divisions.

The two primary measurements of the WFQA are the Mean C and the Floristic Quality Index (FQI). The alder thicket values had a Mean C of 5.42 (transects + meander searches) and 5.34 (transects only) with an FQI of 60.64 (transects + meander searches) and 50.70 (transects only). The sedge meadow values had a Mean C of 5.24 and a FQI of 45.37 (*Carex lacustris*) and a Mean C of 6.24 and FQI of 35.81 (*Carex buxbaumii*). These were exceptionally high values when compared to other wetland types surveyed in Wisconsin. Invasive species were infrequent and most commonly observed in disturbed areas. However, some of the rare, threatened and endangered species were also found in these same disturbed areas.

The WWPBI values for the alder thickets were in the moderate range in comparison to other wetland types investigated in Wisconsin. This model was not as meaningful as the assessments discovered through the WFQA measurements described above. The characteristics of the alder thicket community did not match the vegetative conditions found in depressional wetlands for which this assessment tool was created.

The plant communities of the Pokegama Carnegie Wetland State Natural Area (alder thickets, boreal forest remnants, aspen forest groves and two types of northern sedge meadow) represent an outstanding natural resource for the region and State. A floristic inventory across all community types revealed 318 taxa, representing 161 genera and 56 families.

KEYWORDS: wetland assessment, Pokegama Carnegie Wetlands, Wisconsin Floristic Quality Assessment, Wisconsin Wetland Plant Biotic Index, species diversity

INTRODUCTION

The Pokegama Carnegie Wetlands State Natural Area, hereafter referred to as Pokegama SNA, is located in Douglas County approximately 6.5 kilometers southwest of Superior, Wisconsin. The Pokegama SNA was created in 2006 and is jointly owned by Douglas County and the Wisconsin Department of Natural

Resources (WDNR). This 632 hectare wetland complex is comprised of a northern and southern unit in the Lake Superior Coastal Plain. This study was primarily conducted on the 524 hectares of the south unit, where there were extensive alder thicket communities with infrequent and sporadic sedge meadow complexes. The north unit had extensive sedge meadows with large populations of the threatened species *Petasites frigidus var. sagittatus* (arrowhead sweet-colt's-foot). The north unit is also undergoing a large scale forest restoration, required by the WDNR to mitigate the impacts of transmission lines erected by the American Transmission Company. An 8-hectare, even-aged *Populus tremuloides* (quaking aspen) grove was being converted to a later-stage boreal forest consisting of *Picea glauca* (white spruce) and *Pinus strobus* (white pine) with lesser amounts of *Abies balsamea* (balsam fir) and *Thuja occidentalis* (white cedar). In addition, a 16-hectare *Alnus incana* (speckled alder) thicket was being converted to a coniferous forest of *Larix laricina* (tamarack), *Picea mariana* (black spruce), and *Thuja occidentalis.*

The Pokegama SNA is one of 590 properties designated as a State Natural Area in Wisconsin. It has received special protection due to its high concentrations of rare plants, some of which occur nowhere else in the Lake Superior basin of Wisconsin, as well as its sensitivity to anthropogenic disturbances. The WDNR had limited knowledge of the flora of the Pokegama region, as it does for the vast majority of its state natural areas (R. Hoffman, personal communication).

These attributes, among others, led to a partnership between the University of Wisconsin–Superior, the Lake Superior Research Institute and the WDNR/SNA program in selection of the Pokegama SNA for this combined wetland assessment and floristic inventory project. Collaborative objectives of the project were: field test the Wisconsin Floristic Quality Assessment for Biotic Integrity; field test the Wisconsin Wetland Plant Biotic Index; and to document the vascular species of the Pokegama SNA including mapping any rare plants.

Site Description

The Pokegama SNA is a diverse wetland on the Lake Superior Coastal Plain that is composed primarily of two plant communities: alder thickets and boreal forests. These level, red-clay plains are poorly drained and are situated between the headwaters of the Pokegama and Little Pokegama rivers. These two rivers flow approximately 10 kilometers north into the St. Louis River Estuary at the head of Lake Superior (Figure 1).

Tall shrub wetlands of *Alnus incana* and *Salix* spp. (willows) had the greatest coverage on the Pokegama SNA, with small patches of open sedge meadow dominated by coarse leaved *Carex* spp. (sedges) and *Calamagrostis canadensis* (blue-joint grass). Small, boreal forest "islands" dot the wetland with *Pinus strobus, P. resinosa* (red pine), *Picea glauca, Larix laricina, Betula papyrifera* (paper birch), *Populus balsamifera* (balsam poplar), and *P. tremuloides* being the most common. Of special significance are the numerous populations of rare plants occurring within the wetlands. Rare species observed by Epstein et al. (1997) included: *Caltha natans* (floating marsh-marigold), *Eleocharis nitida* (neat spike-rush), *Geum macrophyllum* (big-leaved avens),

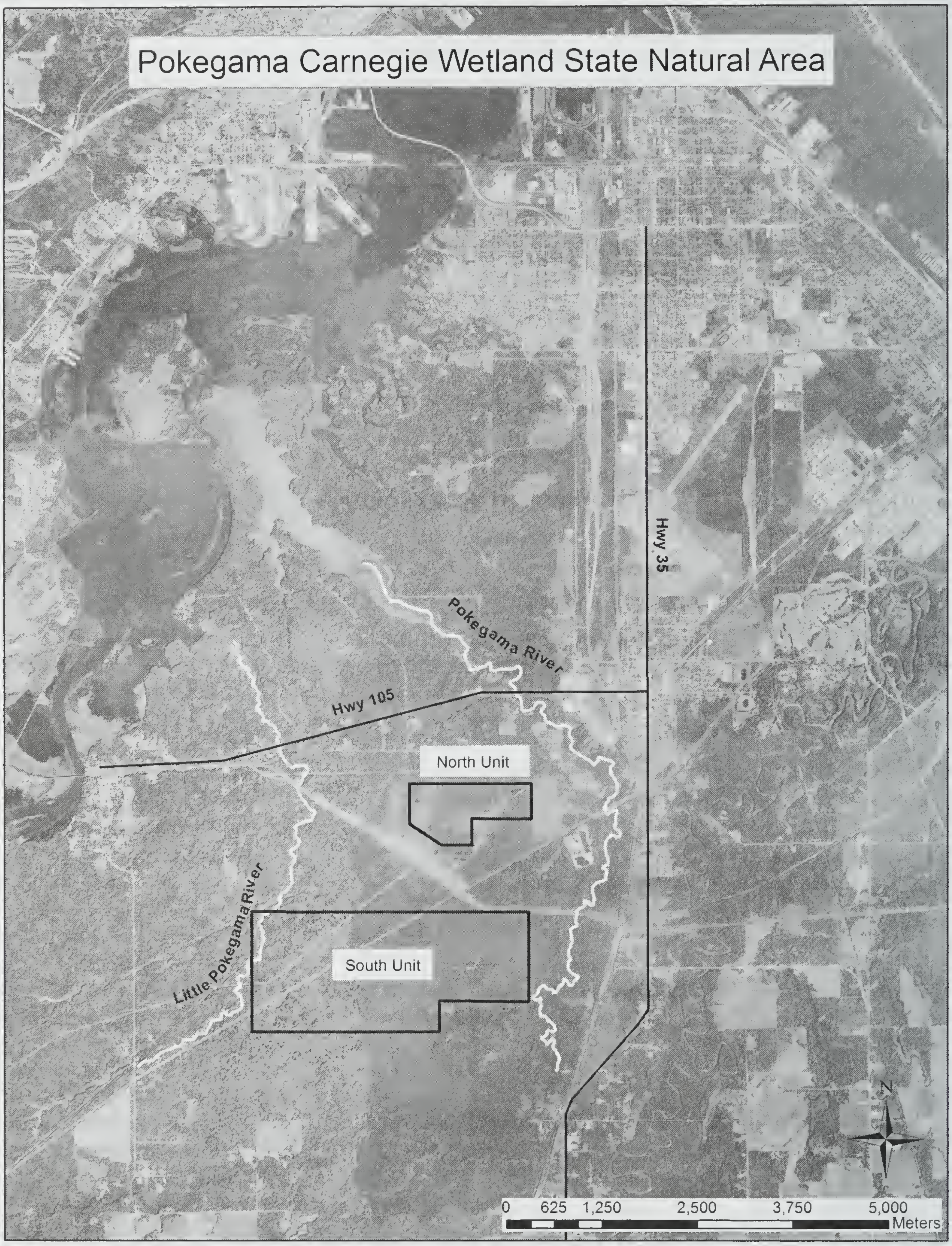
Pokegama Carnegie Wetland State Natural Area
Hwy 35
Pokegama River
Hwy 105
North Unit
South Unit
Little Pokegama River
N
0
625
1,250
2,500
3,750
5,000
Meters

FIGURE 1. The Pokegama Carnegie Wetland State Natural Area is located about 6.5 km south of the city of Superior, in Douglas County Wisconsin. It is comprised of a north and south unit totaling 632 hectares.

Juncus vaseyi (Vasey's rush), *Mertensia paniculata* (northern bluebells), *Petasites frigidus var. sagittatus*, *Ranunculus gmelinii* (Gmelin's buttercup), *Salix planifolia* (diamond-leaf willow), and *Sparganium glomeratum* (clustered bur-reed).

METHODS

Movement through the site was difficult as more than 60% of the area consisted of 3 to 5 meter tall alder thickets. Gas-lines, snowmobile trails and non-designated ATV trails criss-crossed the Pokegama SNA. These disturbed areas were surveyed along with the natural plant communities, and species were recorded when observed. These disturbed areas were divided into wet or dry sites by level of soil saturation.

We employed two primary sampling techniques in order to collect information about the plant communities. These sampling techniques are described below. Unknown specimens were collected and identified in the lab. All unknown specimens were transported temporarily to the University of Wisconsin-Stevens Point for positive identification by Drs. Emmet J. Judziewicz and Robert W. Freckmann.

Meander Search for Rare, Threatened, Endangered (RTE) Species

The Pokegama SNA was delineated and classified into six separate field sections based on plant community homogeneity and practical access to alder thicket aggregates. Five of the six field sections were investigated during the mid-late summer months of 2008. The final field section was surveyed in the spring of 2009. A random pattern was walked within each field section with a focus on covering all unique areas (Goff et al. 1982). Species were recorded when observed, and listed by plant community or disturbance zone. Geographic positioning system (GPS) readings were taken and recorded for all rare, threatened and endangered species. During these searches, special care was taken to list non-native species including information on the size and extent of populations impacting the Pokegama SNA wetland complex.

Each field section was visited once (9-10 hrs/section). It would have been desirable to re-sample each field section several times to capture phenological intervals. Though we are confident that the species list is comprehensive, we are less confident in providing a complete geographic representation of the rare plant species, as some were likely in a dormant or less conspicuous state when surveys were conducted.

Wisconsin Floristic Quality Assessment (WFQA)

WFQA was conducted on the alder thicket and northern sedge meadow plant community types found on the site. This assessment is one method for evaluating the biotic integrity of a site. It should not be construed that the WFQA is a final measurement or a complete analysis of the study area. The technique can be used to compare the floristic quality between similar sites and for tracking changes at the same site over time.

This WFQA method requires an accurate and complete species inventory of the site based on homogeneity of community type. The method is based on species conservatism. Bernthal (2003) described species conservatism as, “the most conservative species require a narrow range of ecological conditions, are intolerant of disturbance, and are unlikely to be found outside un-degraded remnant natural areas, while the least tolerant conservative species can be found in a wide variety of settings and thrive on disturbance”. A numeric value from 0-10 has been designated by leading experts for each vascular species in Wisconsin and is called the Coefficient of Conservatism (C of C) (Bernthal 2003).

There are two formulas that were used in order to create a **Mean C** and a **Floristic Quality Index** (FQI) for each plant community type.

$$\mathbf{Mean\ C = \Sigma\ (c_1 + c_2 + c_3 + \ldots c_n)/N}$$

In the formula, **c** represents the Coefficient of Conservatism for each native species, while **N** is the total number of native species on the site.

$$\mathbf{FQI = Mean\ C * \sqrt{\ } N}$$

The Floristic Quality Index is calculated by multiplying the Mean C by the square root of the total number of native species.

Non-native species were included in the species list and received a C of C of zero (0), but had no influence on the Mean C or FQI calculations.

Wisconsin Wetland Plant Biotic Index (WWPBI)

The WWPBI was developed as a rapid assessment of the plants found in depressional wetlands in Wisconsin. Nine plant community attributes were selected based on their response to human land use practices and disturbances. There is a heavy emphasis on the aquatic plant zones and their dominance and importance values (i.e. emergent, submergent, floating leaf).

Quantitative analysis was used for the WWPBI assessing frequency, percent cover, and importance values for individual species in the alder thickets. A series of 41 (1m × 1m) quadrats were randomly placed for evaluation. A gas pipeline crosses through the Pokegama SNA from the southwest corner to the northeast center of the study area. Twenty of the forty-one quadrats were placed along four transects that ran parallel to this central gas pipeline. These transects started at least 20 meters east and west of the pipeline, to avoid any edge effects. In addition, the quadrats were approximately 200 meters apart along these transects to cover the entire length of the pipeline. The other 21 quadrats were randomly selected independent of the gas pipeline and penetrated further into the alder thicket plant community.

Index calculations

There is a heavy reliance on importance values (IV) in the development of the WWPBI metric. Relative frequency (RF) is calculated by the presence of an individual taxon in each quadrat, measured against the total number of quadrats surveyed. Relative Cover (RC) is based on total amount of coverage in all plots per taxon, measured against the total amount of coverage available in all plots. The importance value provides a quantifiable number in order to rank the more significant taxon to the function of the wetland. In order for a taxon to receive a high IV, both the RF and RC must have high values.

We used the vegetative sampling techniques and importance value calculations of the alder thickets to calculate the WWPBI in comparison to other wetlands. Hauxwell et al. (2004) field tested the WWPBI and developed a ranking system from very poor to excellent utilizing data on 17 depressional wetlands in Wisconsin.

Transect/quadrat Sampling

Quadrats sampled were used to further assess the dominance and cover of species present in the alder thickets. Within each quadrat, all vascular species were identified to the lowest taxonomic level possible. Percent cover was estimated visually for each taxon according to a modified Braun-Blanquet cover class method (Braun-Blanquet, et al. 1932): 1 to <5% (rare), 5 to <25% (occasional), 25 to <50% (common), 50 to <75% (abundant), 75 to 100% (dominant). Total percentage in each quadrat could exceed 100% because canopies of different species overlap one another. If a plant was not identifiable in the field, it was collected, and identified at the Donald W. Davidson Herbarium (SUWS). Plant nomenclature was based on *Flora of North America* (1993+). When the *Flora of North America* was not available, Wetter et al. (2001) was consulted for nomenclature.

RESULTS

Wisconsin Floristic Quality Assessment (WFQA)

A WFQA of the alder thickets and northern sedge meadow types was conducted at the Pokegama SNA. The WFQA measures species richness and tolerance/intolerance of species due to anthropogenic disturbances.

Mean C and FQI are reported in the following ways:

a) Alder thickets—include meander searches and belt transect/frame quadrat techniques
b) Alder thickets—belt transect/frame quadrat
c) Northern sedge meadow *(Carex lacustris)* – meander search
d) Northern sedge meadow *(Carex buxbaumii)* – meander search

Alder Thickets

Eggers and Reed (1987) correlated floristic diversity in alder thickets with the degree of shrub canopy closure. They found that with a denser canopy, species diversity declined. At Pokegama SNA there were extensive areas of extreme canopy closure, but patches of sedge meadow and numerous forest islands punctuated even these thickets. These features of Pokegama SNA characterize the following results.

The WFQA of the alder thickets was measured in two different ways. The first WFQA analysis was conducted using only plant transect/quadrat data. The second WFQA analysis combined the results from the transect data with meander searches.

In the first analysis, the Mean C measurement was 5.34 (transects only), while the second analysis was 5.42 (transects + meander searches). The FQI measurements were greater during the combined methods at 60.64 versus 50.70 for transects alone. The increase in FQI was based on an addition of 36 taxa from the meander search. Species with high C values such as *Caltha natans, Carex disperma* (soft-leaf sedge), *Zizia aurea* (golden alexanders) and others were found only during the meander searchs, elevating the FQI in the combined survey. *Achillea millefolium* (yarrow), *Corylus cornuta* (beaked hazelnut), *Trillium cernuum* (nodding trillium) are edge species from the numerous islands of the northern dry-mesic forest spilling into the alder thickets. These additional species resulted in an elevated number of species in the FQI calculations.

When compared with other wetland types found in Wisconsin, the results of the FQI for the alder thickets were unusually high. In 2002, Emmet Judziewicz (WDNR), field-tested the WFQA measurement for seventeen depressional wetlands throughout the state. His results were compared with our results from this study in Tables 1 and 2. The results for the alder thickets were higher in each category (Mean C = 5.42, # of Native Species = 126, and FQI = 60.64). There are several explanations for these very high numbers.

1. Our amount of time spent surveying on this one site was greater than the earlier field-testing of the FQI on the 17 depressional wetlands, resulting in higher numbers.
2. Our survey activities included mapping of rare plants over the 524 hectares of the Pokegama SNA. Covering this additional ground versus simple transects increased our odds of finding lesser-known species resulting in elevated FQI values.
3. More than 97% of the Pokegama SNA is undisturbed, resulting in species found that are highly intolerant to disturbance.

TABLE 1. Pokegama FQA

	Native Species	Mean C	FQI
Pokegama SNA (Combined) Alder Thickets	126	5.42	60.64
Pokegama SNA (Transects) Alder Thickets	90	5.34	50.70
Pokegama SNA Sedge Meadow: C. lacustris	67	5.24	45.37
Pokegama SNA Sedge Meadow: C. buxbaumii	33	6.24	35.84

TABLE 2. FQA numbers for 17 depressional wetlands in Wisconsin (Judziewicz, 2002)

Site Name	Native Species	Mean C	FQI
Northwest Wisconsin			
Standing Cedars Wetlands, Polk County	20	—	17.2
Waterfowl Prod. Wetlands, Polk County	42	—	22.8
Tatro Wetlands, Polk County	35	—	20.1
North Central Wisconsin			
Oneida County (Site 1—Forest Pond)	26	5.2	26.5
Oneida County (Site 2—H.D. Wetland)	43	—	25.8
Oneida County (Site 3—Pelican Rn. Rd.)	27	5.6	27.4
Northeast Wisconsin			
Sherman Lake, Waushara County	52	—	34.9
Plainfield—W. Marsh, Waushara County	37	—	31.7
Plainfield—E. Marsh, Waushara County	63	5.22	40.4
South Central, WI—Driftless			
Liberty Creek Sedge Meadows Green County	49	—	34.1
Tin Can Alley Wetland Green County	30	—	25.9
South Central, WI—Glacial			
Diedrich—Alex. Wetland, Jefferson County	43	—	27.6
Hope Road Wetlands/Bork, Dane County	29	—	17.3
Fayeville Pr. Scrape, Jefferson County	26	—	17.1
Southeast Wisconsin			
Myra Wetland, Washington County	39	—	26.9
Beyer's Pond Ozaukee, County	20	—	18.1
Seidler Farm, Ozaukee County	22	—	14.1

4. Northern wetland types as a rule have less disturbance activities (i.e. agriculture, urban development, highways, etc.) than the wetlands in other portions of the State. These disturbances result in a decline in species diversity often resulting in non-native invasive species increasing, which was not observed at the Pokegama SNA.

Sedge Meadows

The two sedge meadow communities [*Carex lacustris* (common lake sedge) and *Carex buxbaumii* (Buxbaum's sedge)] make up less than 3% of the site.

Carex lacustris meadows represent 95% of all sedge meadows on site, and the best homogenous examples are in the northern unit. A total of 75 native species and 4 non-native invasive species were found during our meander searches. We were able to include a private contractor's information in our late season list to provide a more complete inventory for this plant community type (G. Walton, personal communication). Like the alder thickets, these sedge meadows had high numbers with a Mean C of 5.24 and a FQI of 45.37.

We were only able to locate one *Carex buxbaumii* community to investigate in the south unit and the survey was conducted in early June of 2009. As expected the Mean C was high at 6.24, but the FQI was lower than the *Carex lacustris* meadow at 35.84. It is likely that this smaller FQI value reflects our survey limitation and not the community as a whole.

Wisconsin Wetland Plant Biotic Index (WWPBI)

The plant biotic index is a multimetric index based on relative importance values (IV) (percent cover and frequency of occurrence) of nine community attributes based on taxonomic divisions (Lillie 2000). This tool was initially developed to investigate depressional wetlands that hold water less than one year and are isolated from other bodies of water. Prior to investigation of the Pokegama SNA, we anticipated large numbers of small pools that would fit into this category based on earlier descriptions of the SNA (Epstein, et al. 1997). These pools may have been present in the spring, but our study was restricted to surveying after July 1st. During the next two months, no pools of any size were located. Instead, we focused our investigation in the saturated, but not wet scrub/shrubs of the alder thickets. The results listed in Table 3 are based on cover, frequency and importance values and applying the WWPBI metric.

The WWPBI values we identified were in the mid-range in comparison to other wetland types investigated in Wisconsin (Lillie 2000). This model was not as meaningful as the assessments discovered through the FQA measurements described above. The alder thicket community characteristics do not match the vegetative conditions found in depressional wetlands, for which this assessment tool was created.

Table Attributes

Total taxa was in the high value with 94 species found in 41 quadrats

***Carex* spp.** were mid-range in diversity and IV's were lower

Reed Canary Grass was absent

Typha was absent

Lemna was absent

Calamagrostis canadensis was abundant and mid-range in importance value in almost every quadrat

Good Taxa (*Carex, Utricularia, Potamogeton, Calamagrostis, Sagittaria, Persicaria, and Equisetum)* were mid-range in IV due to the fact that emergent and submergent zones were absent in this wetland community

Pondweed was absent

Floating Leaf Macrophyte was absent

TABLE 3. Wisconsin Wetland Plant Biotic Index for Pokegama SNA alder thickets.

Taxa	Attributes	Value	Metric Score
Total Taxa	Count	94	5
Carex	IV	0.133	3
Reed Canary Grass	IV	0	5
Typha	IV	0	5
Lemna	IV	0	5
Calamagrostis	IV	0.084	5
Good Taxa	IV	0.3	3
Pondweed	IV	0	1
Floating Leaf Macrophyte	Percent	0	1
Total Score			33

WWPBI assessment tool recommends surveying 18 quadrats over three transects that cross through the shrub edge, wet meadow, emergent and submergent zones found in depressional wetlands. The alder thickets did not possess some of these zones.

Of the nine attributes, only four were present in the scrub/shrub alder thickets of the Pokegama SNA. The WWPBI metric misrepresented the ecological value of these wetlands. Three of the attributes resulted in high metric scores based on the ecological integrity of the wetland. On the other hand, the values for the pondweed and floating leaf attributes distorted the overall metric score due to their absence.

Using the same plant sampling data as used for the WWPBI metric, the next section provides additional evaluation of the composition, dominance, and importance values of all taxa found during the vegetative survey of the alder thickets.

Transect/Quadrat Analysis (Alder Thickets)

The two most dominant taxa in the alder thickets were *Alnus incana* and *Calamagrostis canadensis;* these taxa constituted more than 50% of all cover value in the survey. The remaining 50% cover value was represented by 92 other taxa identified in the 41 quadrats surveyed. Other dominant species identified in Table 4 included *Carex lacustris, Rubus idaeus* (red raspberry), *Equisetum sylvaticum* (wood horsetail), *Impatiens capensis* (orange jewelweed), *Salix petiolaris* (meadow willow), *Dryopteris cristata* (crested shield fern), and *Salix pyrifolia* (balsam willow).

Total taxa were divided into five classes based on the modified Braun-Blanquet method (dominant, abundant, common, occasional, and rare). The dominants (9 taxa) represented 10% of the floral diversity. Abundant, common and occasional combined classes consisted of 73 taxa representing 78% of the floral diversity found in these thickets. Lastly, the rare category had 12 taxa present representing 13% of the floral diversity, though these were not necessarily rare plants.

The rare cover plants discussed in Table 5 indicate the scarcity of these species in our quadrat surveys.

Patches of sedge meadows and numerous forest islands punctuate the alder thickets, creating more opportunities for edge species to be present in the quadrat surveys. Some of the species in this table are from other plant communities and they are not typical representatives of the alder thickets. These species included: *Betula papyrifera, Lactuca biennis* (tall blue lettuce), *Ribes cynosbati* (eastern prickly gooseberry), *Thalictrum dioicum* (early meadow-rue), *Uvularia grandiflora* (large-flowered bellwort), and *Viola sororia* (door-yard violet). Rather surprisingly, other species common to northern wetlands, but rarely found in our survey, were: *Cirsium muticum* (swamp thistle), *Lysimachia ciliata* (fringed

TABLE 4. Dominant Vegetation of the alder thickets

Species	Importance Value
Alnus incana	0.15
Calamagrostis canadensis	0.08
Carex lacustris	0.05
Rubus idaeus	0.05
Equisetum sylvaticum	0.04
Impatiens capensis	0.03
Salix petiolaris	0.03
Dryopteris cristata	0.02
Salix pyrifolia	0.02

TABLE 5. Cover Classes

Class	Importance Value	No. of Taxa	% of Total Taxa
Dominant	0.154 to 0.02	9	10%
Abundant	0.02 to 0.01	18	19%
Common	0.009 to 0.003	31	33%
Occasional	0.0029 to 0.0015	24	25%
Rare	0.0014 to 0.0011	12	13%

loosestrife), *Scutelleria galericulata* (common skullcap), *S. lateriflora* (blue skull cap), and *Sium suave* (water parsnip).

As listed in Table 6, only two of the seven rare, threatened and endangered species were found in the transect surveys. Both species were part of the **common** cover class indicating that the habitat conditions (i.e. wetland soils, topography, hydrology, plant associates) in concert with low anthropogenic stress resulted in healthy populations of these two species.

PLANT COMMUNITIES

There were five major plant community types found at the SNA: alder thickets, boreal forest remnants, aspen forest groves and two types of northern sedge meadows. Alder thickets were the dominant plant community. Figure 2 shows the site delineated. Figure 3 provides a view of the wetlands.

Alder Thickets

Representing the largest plant community on the Pokegama SNA with 61% land cover, the alder thickets were a minerotrophic wetland community dominated by tall shrubs, especially *Alnus incana*. Shrub associates included: *Ilex verticillata* (common winterberry), *Rubus idaeus*, *Salix petiolaris, Salix pyrifolia*, *Viburnum opulus* (American cranberry-bush), and *Viburnum lentago* (nannyberry). Characteristic herbaceous species present included: *Campanula aparinoides* (marsh bellflower), *Comarum palustre* (marsh cinquefoil), *Eupatorium perfoliatum* (boneset), *Impatiens capensis, Galium trifidum* (northern three-lobed bedstraw), *G. triflorum* (fragrant bedstraw), *Onoclea sensibilis* (sensitive fern), *Persicaria amphibia* (water smartweed), *P. sagittata* (arrow-leaved tear-thumb), and *Symphyotrichum puniceum* (purple-stemmed aster).

The alder thickets at Pokegama SNA were well-established, occupying large areas formerly covered by coniferous swamps that were logged in the early 1900's; since that time water tables have risen. Stands of alder that originated following logging and wildfire will usually revert to forest, but at Pokegama SNA, the soils are heavy and poorly drained and forest re-growth is problematic

TABLE 6. Wisconsin rare plants found in survey

Wisconsin rare plants	Importance Value	Frequency
Petasites frigidus var. *sagittatus*	0.00664	3 quads
Salix planifolia	0.00747	3 quads

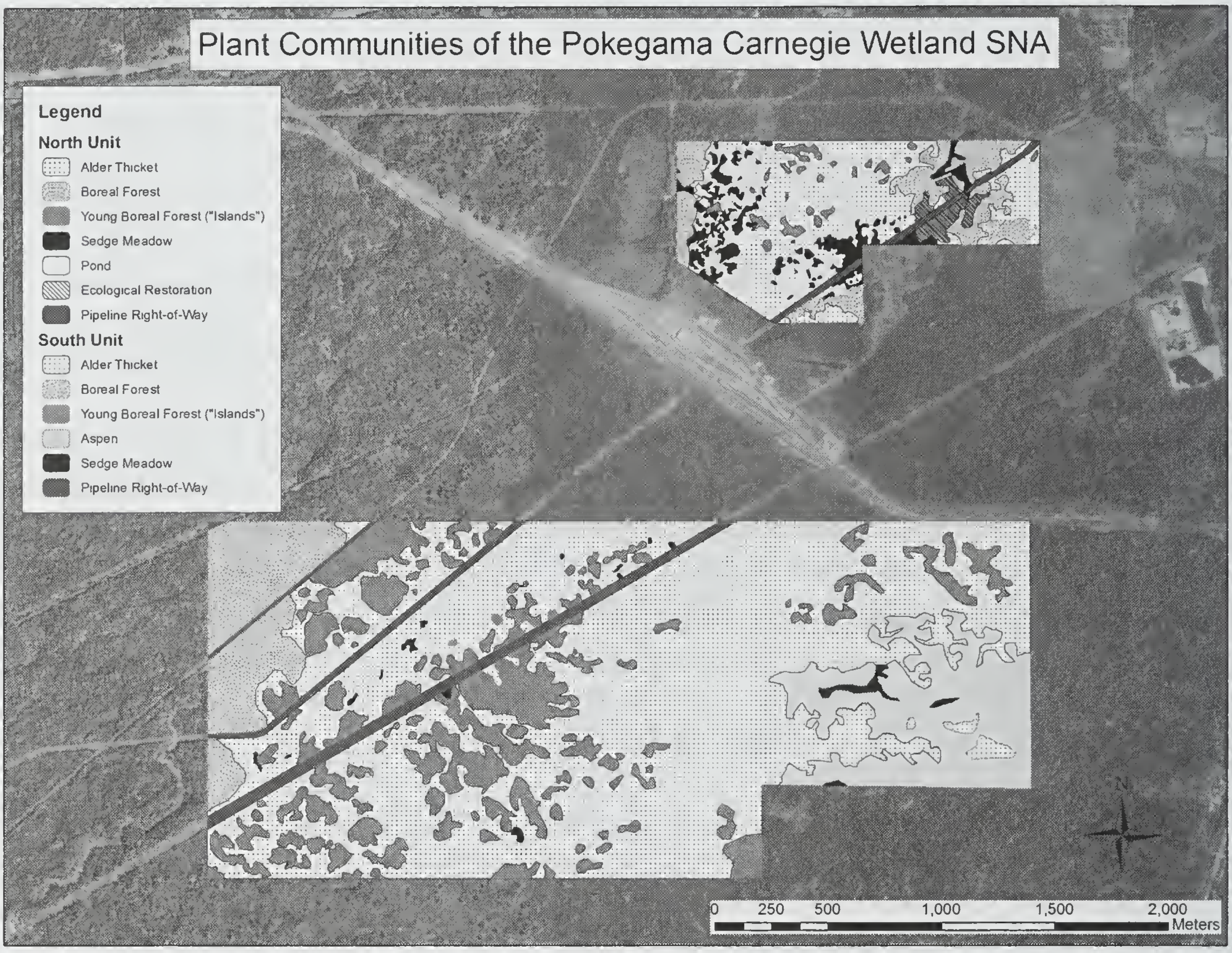
Plant Communities of the Pokegama Carnegie Wetland SNA
Legend
North Unit
Alder Thicket
Boreal Forest
Young Boreal Forest ("Islands")
Sedge Meadow
Pond
Ecological Restoration
Pipeline Right-of-Way
South Unit
Alder Thicket
Boreal Forest
Young Boreal Forest ("Islands")
Aspen
Sedge Meadow
Pipeline Right-of-Way
N
0 250 500 1,000 1,500 2,000
Meters

FIGURE 2. The plant communities of the Pokegama Carnegie Wetland SNA are delineated here. The dominant plant community was the alder thicket, followed by the young boreal forest “islands”. Sedge meadows were much more extensive in the northern unit of the SNA.

owing to “swamping effects” (Karamanski 1989). Curtis (1959) and Heinselman (1963) reported that these conifer swamps were converted to alder thickets throughout the Great Lakes region.

Boreal Forest “Islands”

There were small “islands” of boreal forest (88 hectares) found throughout the southern unit of the Pokegama SNA (524 hectares). There was also a small forest stand dominated by *Populus tremuloides* (51 hectares) in the southeast corner, while a mature stand of boreal forest (39 hectares) hugs the rugged terrain of the east branch of the Little Pokegama River in the northwest corner of the Pokegama SNA. These combined forests represent 34% of the land cover. Several walk throughs were conducted through these forests to add to the species inventory for the Pokegama SNA.

The boreal forest remnants were dominated by *Picea glauca, Pinus strobus, Betula papyrifera, Populus balsamifera, Populus tremuloides*, and *Thuja occidentalis*. *Abies balsamea,* commonly found in most boreal forest communities, was infrequent at the Pokegama SNA. Common understory herbs include *Aralia nudicaulis* (wild sarsaparilla), *Clintonia borealis* (yellow blue-bead-lily), *Cornus canadensis* (bunchberry), *Eurybia macrophylla* (big-leaved aster), and *Maianthemum canadense* (wild lily-of-the-valley).

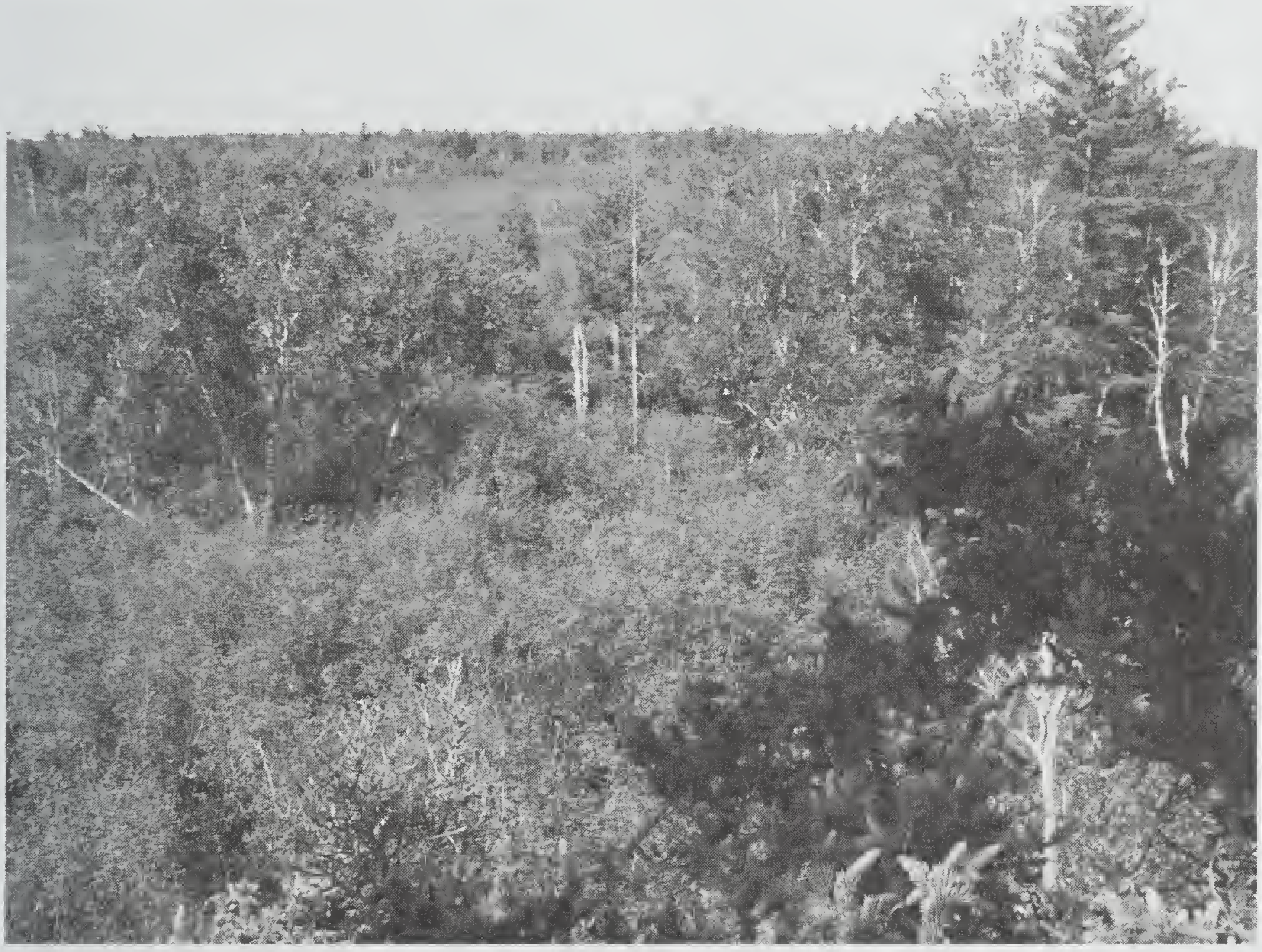

FIGURE 3. A view of the Pokegama Carnegie Wetlands State Natural Area. This photograph was taken from the top of a tree on the edge of a forest "island" within a larger area of alder thicket. The light colored trunks are predominantly aspen. (Photograph by Josh Horky, 11 June 2009).

Of potential interest from the perspective of vegetation classification and restoration, Curtis (1959) discussed white pine having the highest importance value of any tree in the Lake Superior region, as recorded during the original land survey of the mid-1800's. The public land surveys of the Pokegama SNA area recorded *Pinus strobus, Larix laricina, Thuja occidentalis, Picea glauca,* and *Abies balsamea* as dominant trees, while *Alnus incana and Corylus* spp. occupied the forest understory (Stuntz, 1852–1854). Today on the Pokegama SNA, only large white pine trees >20 inch dbh exist with sporadic re-generation on the forested islands.

Northern Sedge Meadows

This open wetland community makes up 3% or 16 hectares of land cover, with 90% found in the northern unit. These northern wet meadows were dominated by sedges and grasses. There were three common subtypes:

1. Tussock meadows, dominated by *Carex stricta* (tussock sedge) and *Calamagrostis canadensis.*
2. Broad-leaved sedge meadows were dominated by the robust sedges *Carex lacustris* and *C. utriculata* (yellow lake sedge)
3. Wire-leaved sedge meadows were dominated by such species as *Carex*

buxbaumii, Carex oligosperma (few-seeded sedge), and the broad-leaved sedge *Carex lacustris.*

Of the three, the broad-leaved sedges were the most dominant. Frequent herbaceous associates included *Symphyotrichum lanceolatum* (white panicled aster), *Eutrochium maculatum* (spotted joe-pye-weed), *Mentha arvensis* (field mint), and *Solidago gigantea* (giant goldenrod). The graminoids were represented by *Glyceria striata* (fowl mana grass), *Juncus brevicaudatus* (narrow-panicle rush), *Leersia oryzoides* (rice cut grass), *Poa palustris* (marsh bluegrass), *Schoenoplectus tabernaemontani* (soft-stem bulrush), and *Scirpus cyperinus* (woolgrass). *Sphagnum* mosses were mostly absent, but when found, occurred in scattered, discontinuous patches.

Site Inventory

The species list found in Appendix A is a combined list from all vegetative sampling methods described above and represents a cross-section across all natural plant communities and disturbed areas found at Pokegama Carnegie Wetlands. The vascular plant list included 318 taxa, representing 161 genera and 56 families. There were 10 fern and fern allies, 8 gymnosperms and 300 angiosperms. Of the angiosperms, 94 were monocots and 206 were dicots. The predominant plant families observed were Asteraceae (46 taxa), Cyperaceae (39 taxa), Rosaceae (23 taxa), Poaceae (22 taxa), and Ranunculaceae (16 taxa).

Observations were recorded in four natural plant community types (alder thickets, two northern sedge meadow types, a mixture of boreal and northern dry-mesic forests remnants), a ¼ hectare pond in the northern unit, and several disturbed areas. These disturbed areas include gas pipelines, a designated county snowmobile trail, ATV trails, and in the north unit an old railroad grade. There were 169 taxa in the northern dry mesic forest/boreal forest remnants, 68 taxa in the *Carex lacustris* sedge meadow, 33 taxa in the *Carex buxbaumii* sedge meadow, 133 taxa in the alder thickets, 60 taxa in the pond and its surrounding shore, 40 taxa in dry disturbed areas and 41 taxa in wet disturbed areas including the rare *Eleocharis nitida* and *Sparganium glomeratum.*

Thirty-two taxa were found that are introduced non-native species to Wisconsin. Of the 93 taxa found in the alder thicket quadrat surveys, only three invasive taxa were found: *Phleum pratense* (timothy), *Poa annua* (annual bluegrass), *and Ranunculus acris* (common buttercup). Frequency, cover and importance values were low for each of these species. The remaining introduced non-native species were observed during meander surveys and were confined to the dry and wet disturbed areas (Table 7). Based on these vegetative surveys, we estimate non-native species occupy < 2% of total area of the SNA.

Rare, threatened and endangered plant populations were well represented throughout the north and south units of the Pokegama Carnegie Wetland. Populations of *Petasites frigidus var. sagittatus* (Figure 4) and *Salix planifolia* were extensive and found both in the alder thickets and sedge meadows while some *Juncus vaseyi* populations were found in the northern unit. *Caltha natans* was represented by only one specimen located in a drainage area found deep in the alder thickets. *Geum macrophyllum* var. *macrophyllum* was observed numerous

TABLE 7. Introduced species found at Pokegama SNA

Agrostis gigantea	*Hieracium aurantiacum*	*Melilotus officinalis*	*Salix X rubens*
Alopecurus pratensis	*Hieracium caespitosum*	*Phalaris arundinacea*	*Sonchus oleraceus*
Barbarea vulgaris	*Juncus articulatus*	*Phleum pratense*	*Tanacetum vulgare*
Beckmannia syzigachne	*Leucanthemum vulgare*	*Poa annua*	*Taraxacum officinale*
Cirsium arvense	*Lonicera morrowii*	*Poa pratensis*	*Trifolium hybridum*
Cirsium vulgare	*Lonicera tatarica*	*Potentilla recta*	*Trifolium pratense*
Elytrigia repens	*Lotus corniculata*	*Ranunculus acris*	*Trifolium repens*
Elytrigia smithii	*Lythrum salicaria*	*Rumex crispus*	*Valeriana officianlis*

times in the boreal forests remnants. Two large populations (> 1000 plants) and one isolated colony of *Mertensia paniculata* were located in or near the Pokegama SNA. *Eleocharis nitida* and *Sparganium glomeratum* had small populations and were found only in disturbed wet areas. *Potamogeton vaseyi* was found in the northern pond in early September. *Ranunculus gmelinii* was not observed during our survey work, but was recorded by Epstein et. al (1997). A listing of these rare plants can be found in Table 8.

In addition to rare plants, we found eight taxa that were new county records for Douglas County, Wisconsin. *Canadanthus modestus* (great northern bog aster) is a new Wisconsin record and was found only in the northern unit in three small populations (Figure 5). Specimens were deposited both at the UW – Madi-

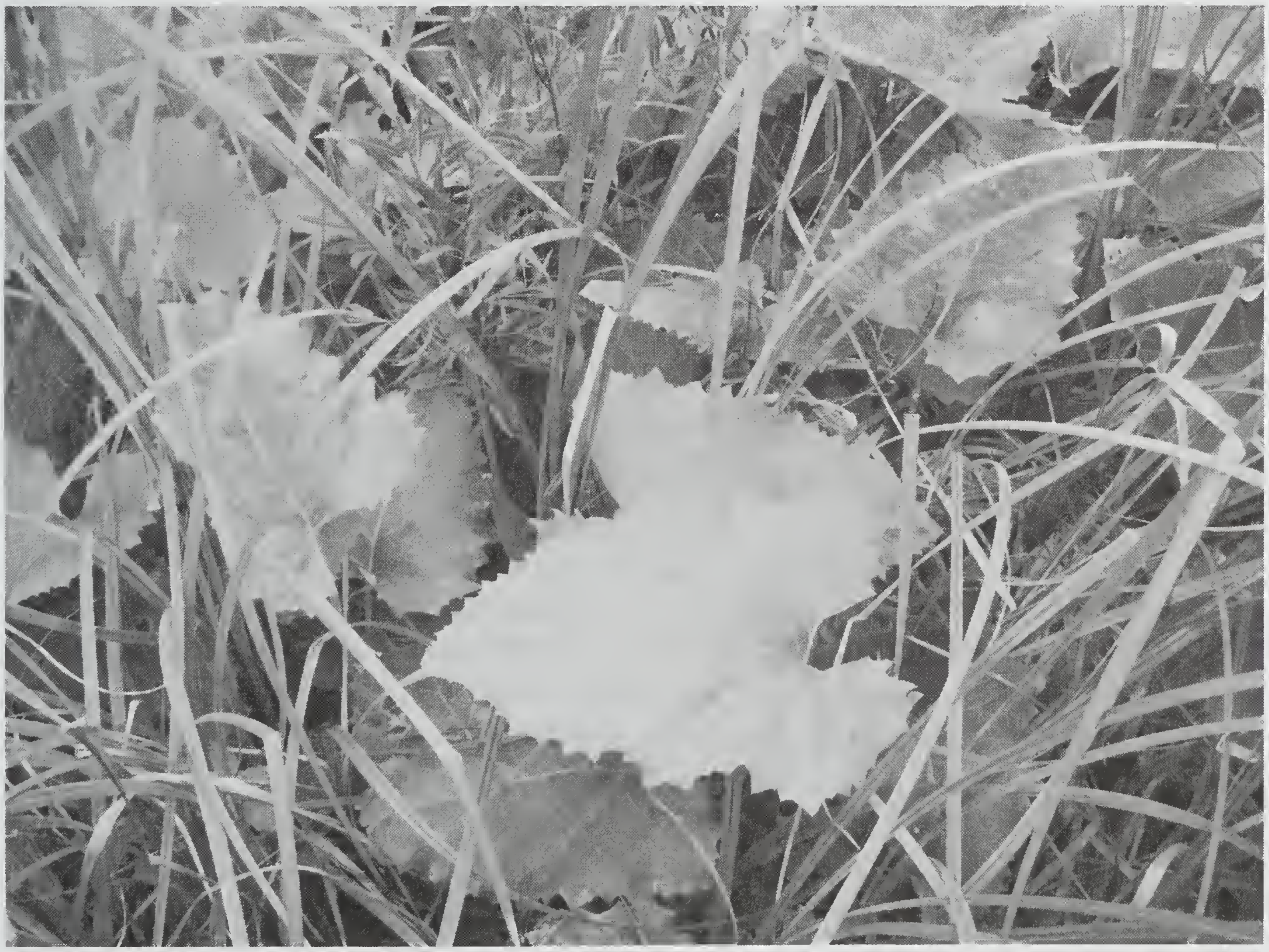

FIGURE 4. Vegetative leaves of arrowhead sweet-colt's-foot (*Petasites frigidus* var. *sagittatus* (Banks ex Pursh) Chern.). This distinctive, threatened plant was one of the more commonly observed rare species in the SNA. (Photograph by Paul Hlina, 22 August 2008).

TABLE 8. Rare species of the Pokegama SNA

Status	Species	Habitat	No. Occurrences
Endangered	*Caltha natans*	Alder Thicket	1
Endangered	*Eleocharis nitida*	Wet Disturbed Trail	100s
Special Concern	*Geum macrophyllum* var. *macrophyllum*	Forest	>50 plants
Special Concern	*Juncus vaseyi*	Pond/Sedge Meadow	>10
*	*Mertensia paniculata*	Forested riverbanks	2 populations, >1000 plants
Threatened	*Petasites frigidus* var. *sagittatus*	Alder Thicket/Sedge Meadow	>100 populations
**	*Petasites frigidus* X *vitifolius*	Alder Thicket/ Sedge Meadow, forests	>100 plants
Special Concern	*Potamogeton vaseyi*	Pond	1
Threatened	*Salix planifolia*	Alder Thicket	>100 plants
Threatened	*Sparganium glomeratum*	Wet Disturbed Pipeline	1

*Potential Special Concern species

** Hybrid species: Cross between *Petasites frigidus* var. *palmatus* and *P. frigidus* var. *sagittatus*

son (WIS) and Donald W. Davidson (SUWS) herbaria. A complete list of these taxa, their habitat and occurrences can be found in Table 9.

CONCLUSIONS

The WFQA sampling technique was developed by the Wisconsin Department of Natural Resources in 2003 as a level 3 wetland assessment method (Available online at: http://dnr.wi.gov/wetlands/methods.html). Field testing at the Pokegama SNA proved to illustrate the high value and biotic integrity of wetland types found in the northwest corner of Wisconsin when compared and contrasted with other Wisconsin wetlands.

In contrast, the WWPBI metric was a poorly chosen wetland assessment tool for assessing this scrub/shrub dominated wetland plant community, but provides more information on improving or modifying the assessment tool. With modifications, the WWPBI metric would better represent this wetland type by assigning more weight to the attributes present than to the ones absent.

The Pokegama SNA plant communities represent an outstanding natural resource for the region. Further human development activities in this area could have detrimental effects on the sensitive, unique characteristics of the area. The floristic quality assessment clearly indicated a wetland community of high value. Invasive species were infrequent, most commonly observed in disturbed areas. However, some of the rare, threatened and endangered species were also found in these same disturbed areas. Species diversity and conservatism may decrease if stem density in the alder thickets become so dense that their canopies shade out other plants, which may have a negative effect on the value of the community. The numerous small pools described by the WDNR in the 1997 description were not found during our two season survey. This may be an indication of hydrological shifts, natural variations of wet and dry cycles, or a changing climate.

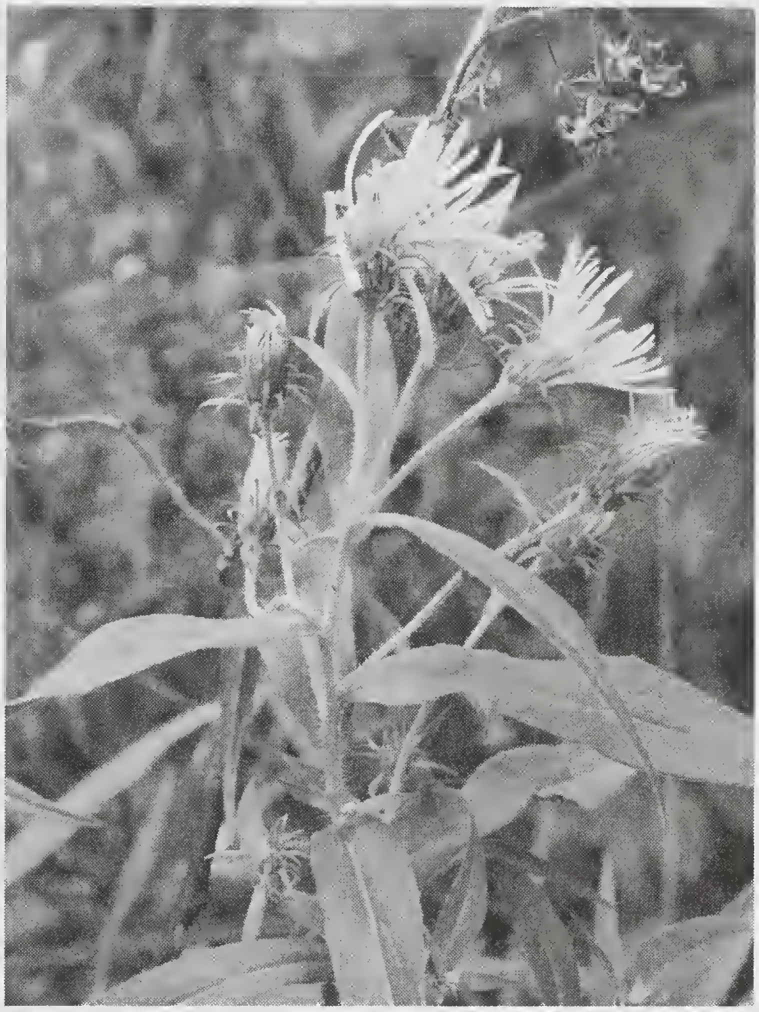

FIGURE 5. Great northern bog aster (*Canadanthus modestus* (Lindl.) G. L. Nesom.) was discovered in the north unit of the Pokegama Carnegie Wetlands State Natural Area in three small populations. This was the first time this species has been documented in Wisconsin. (Photograph by Scott Namestnik, Botanist, JFNew, 3 September 2008).

All of these factors will have implications for future management decisions by the Wisconsin Department of Natural Resources.

ACKNOWLEDGMENTS

This project was a collaborative effort between Wisconsin Coastal Management, the University of Wisconsin – Superior, and the Wisconsin Department of Natural Resources – State Natural Area Program from July 2008–June 2009. We extend our thanks to the following individuals: Josh Horky, Cameron Bertsch, Benjamin Hlina, Christine Ostern, Greta Pearson, Nicole Kalkbrenner and Gary Walton, who assisted in collection of field data, photographs and maps, and the preparation of herbarium specimens. A special thank you is extended to Ryan Magana, Department of Natural Resources, State Natural Area Specialist who assisted in site selection and development of our methodology for the project. Our deepest gratitude is extended to Dr. Emmet Judziewicz and Dr. Robert Freckmann of the University of Wisconsin–Stevens Point for their assistance in plant identification and knowledge of plant distribution throughout the state of Wisconsin. Dr. Galen Smith's work with the projects' *Carex* and *Eleocharis* taxons was extremely valuable and we are deeply indebted for his services. The project could not have been completed without the support, time and encouragements of Dr. Mary Balcer, Director of the Lake Superior Research Institute and the administrative support

TABLE 9. New Douglas County, Wisconsin Records

Species	Habitat	No. Occurrences
Bidens trichosperma	Wet Disturbed Area	2 plants
Canadanthus modestus	Shaded Wet Forest	3 populations; 60 plants
Carex atherodes	Graminoid floodplain	1000s
Carex lupulina	Alder Thickets	3 Plants
Carex radiata	Alder Thickets	Numerous
Geum macrophyllum var. *macrophyllum*	Aspen Forests	>50 Plants
Helianthus grosserseratus	Dry Disturbed Area/RR Grade	Numerous
Puccinellia pallida	Wet Disturbed Area/Pipeline	1 Plant

of Ardeen Stoll. We greatly appreciate the matching funds provided for the project by the Douglas County Land and Water Conservation Board. We also wish to thank our reviewers of this manuscript with their helpful comments on several drafts before we reached our final copy. They are Dr. Kurt Schmude and Dr. Nicholas Danz of the University of Wisconsin – Superior. Our last thanks is extended to Wisconsin Coastal Management Program for funding this project through Grant #ADO90091-009.02 for the duration of the study.

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APPENDIX A

POKEGAMA CARNEGIE WETLANDS SPECIES INVENTORY

PTERIDOPHYTES

DENNSTAEDTIACEAE (BRACKEN FAMILY)

Pteridium aquilinum (L.) Kuhn. var. *latiusculum* (Desv.) Underw. ex A. Heller, bracken fern

DRYOPTERIDACEAE (WOOD FERN FAMILY)

Athyrium filix-femina (L.) Roth ex. Mert. var. *angustum* (Willd.) G. Lawson, lady fern
Dryopteris carthusiana (Vill.) H.P. Fuchs., spinulose wood fern
D. cristata (L.) A. Gray, crested shield fern
Matteuccia struthiopteris (L.) Todora var. *pensylvanica* (Willd.) C.V. Morton, ostrich fern
Onoclea sensibilis L., sensitive fern

EQUISETACEAE (Horsetail Family)

Equisetum arvense L., common horsetail
E. fluviatile L., water horsetail (1220)
E. sylvaticum L., wood horsetail

THELYPTERIDACEAE (Marsh Fern Family)

Thelypteris palustris Schott. var. *pubescens* (Lawson) Fernald, marsh fern

GYMNOSPERMS

CUPRESSACEAE (Cypress Family)

Thuja occidentalis L., northern white-cedar

PINACEAE (Pine Family)

Abies balsamea (L.) Mill., balsam fir
Larix laricina (Du Roi) K.Koch, tamarack
Picea glauca (Moench) Voss, white spruce
P. mariana (Mill.) Britton, Sterns & Poggenb., black spruce
Pinus banksiana Lamb., jack pine
P. resinosa Aiton, red pine
P. strobus L., eastern white pine

DICOTYLEDONS

ACERACEAE (Maple Family)

Acer rubrum L. var. *rubrum*, red maple
A. spicatum Lam., mountain maple

APIACEAE (Carrot Family)

Cicuta bulbifera L., bulblet water hemlock (1157, 1185)
C. maculata L., common water-hemlock
Heracleum lanatum Michx., American cow-parsnip
Osmorhiza claytonii (Michx.) C.B.Clarke, hairy sweet cicely
O. longistylis (Torr.) DC., smooth sweet cicely
Sanicula marilandica L., black snakeroot
Sium suave Walter, water parsnip
Zizia aurea (L.) W.D.J.Koch, golden alexanders

APOCYNACEAE (Dogbane Family)

Apocynum androsaemifolium L., spreading dogbane

AQUIFOLIACEAE (Holly Family)

Ilex mucronata (L.) M. Powell, V. Savolainen & S. Andrews, catberry
I. verticillata (L.) A. Gray, common winterberry

ARALIACEAE (Ginseng Family)

Aralia nudicaulis L., wild sarsaparilla
A. racemosa L., American spikenard

ARISTOLOCHIACEAE (Birthwort Family)

Asarum canadense L., wild-ginger

ASTERACEAE (Aster Family)

Achillea millefolium L., yarrow
Anaphalis margaritacea (L.) Benth. & Hook.f., pearly everlasting
Antennaria neglecta Greene, field pussy-toes
A. parlinii Fernald, plantain pussy-toes
Bidens cernua L., nodding beggar-ticks

B. connata Muhl. ex Willd, purple-stem beggar-ticks (1163)
B. trichosperma (Michx.) Britton, swamp beggar-ticks
B. vulgata Greene, tall beggar-ticks
Canadanthus modestus (Lindl.) G.L. Nesom., great northern bog aster (1167), New record for Wisconsin
**Cirsium arvense* (L.) Scop., canada thistle
C. muticum Michx., swamp thistle
**C. vulgare* (Savi) Ten., bull thistle
Doellingeria umbellata (Mill.) Nees, flat-top aster
Erigeron philadelphicus L., common fleabane
E. strigosus Muhl. ex Willd, daisy fleabane
Eupatorium perfoliatum L., boneset
Eurybia macrophylla (L.) Cass., big-leaved aster
Euthamia graminifolia (L.) Nutt., grass-leaved goldenrod
Eutrochium maculatum (L.) Lamont, spotted joe-pye-weed
Helianthus giganteus L., giant sunflower
H. grosseserratus M. Martens, saw-tooth sunflower
Heliopsis helianthoides (L.) Sweet, ox-eye (1164)
**Hieracium aurantiacum* L., devil's-paintbrush
**H. caespitosum* Dumort., field hawkweed
H. umbellatum L., Canada hawkweed
Lactuca biennis (Moench) Fernald, tall blue lettuce
**Leucanthemum vulgare* Lam., ox-eye daisy
Packera paupercula (Michx.) A. Löve & D. Löve, northern ragwort
Petasites frigidus var. palmatus (Aiton) Cronquist, arctic sweet-colt's-foot
P. frigidus var. *sagittatus* (Banks ex Pursh) Chern., arrowhead sweet-colt's-foot (1199)
P. frigidus X vitifolius (Greene) Chern., sweet-colt's-foot (1247)
Prenanthes alba L., white-lettuce
Rudbeckia hirta L. var. *pulcherrima* Farw., black-eyed susan
Solidago canadensis L., Canada goldenrod
S. gigantea Aiton, giant goldenrod
S. speciosa Nutt., showy goldenrod (1227)
S. uliginosa Nutt., northern bog goldenrod (1171)
**Sonchus oleraceus* L. field sow-thistle
Symphyotrichum boreale (Torr.& A.Gray) A. Löve & D. Löve, northern bog aster
S. ciliolatum (Lind.), A. Löve & D. Löve, northern heart-leaved aster (1225)
S. lanceolatum (Willd.) G. L. Nesom, white panicled aster
S. lanceolatum (Willd.) G. L. Nesom var. *interior* (Wieg.) G. L. Nesom, white panicled aster
S. lateriflorum (L.) A. Löve & D. Löve, calico aster
S. puniceum (L.) A. Löve & D. Löve, purple-stemmed aster
**Tanacetum vulgare* L., common tansy
**Taraxacum officinale* F. H. Wiggers, common dandelion

BALSAMINACEAE (Touch-me-not, Jewelweed Family)
Impatiens capensis Meerb., orange jewelweed

BETULACEAE (Birch Family)
Alnus incana (L.) Moench ssp. *rugosa* (Du Roi) R.T.Clausen, speckled alder
Betula papyrifera Marshall, white birch
B. pumila L., bog birch (1174)
Corylus americana Walter, American hazelnut
C. cornuta Marshall ssp. *cornuta,* beaked hazelnut

BORAGINACEAE (Borage Family)
Cynoglossum boreale Fernald., northern wild comfrey
Mertensia paniculata (Aiton) G. Don var. *paniculata,* northern blue bells

BRASSICACEAE (Mustard Family)
**Barbarea vulgaris* R.Br., yellow-rocket

CAMPANULACEAE (Bellflower, Bluebell Family)
  Campanula aparinoides Pursh, marsh bellflower

CAPRIFOLIACEAE (Honeysuckle Family)
  Diervilla lonicera Mill., northern bush-honeysuckle
  Lonicera canadensis W.Bartram ex Marshall, American fly honeysuckle
  L. dioica L., red honeysuckle
  L. hirsuta Eaton, hairy honeysuckle (1187)
  **L. morrowii* A. Gray, Asian fly honeysuckle
  **L. tatarica* L., tartarian honeysuckle
  Viburnum lentago L., nannyberry
  V. opulus L. ssp. *trilobum* (Marshall) R. T. Clausen, American cranberry-bush
  V. rafinesquianum Schult., arrow-wood

CARYOPHYLLACEAE (Pink Family)
  Stellaria longifolia Muhl. ex Willd., long-leaved stitchwort (1280)

CONVOLVULACEAE (Morning-glory Family)
  Calystegia sepium (L.) R.Br., hedge bindweed

CORNACEAE (Dogwood Family)
  Cornus canadensis L., bunchberry
  C. rugosa Lam., round-leaved dogwood
  C. stolonifera Michx., red osier dogwood

ERICACEAE (Heath Family)
  Chamaedaphne calyculata (L.) Moench, leather-leaf
  Pyrola americana Sw., round-leaved shin-leaf
  P. chlorantha Sw. green-flowered shinleaf
  P. elliptica Nutt., elliptic shin-leaf
  Rhododendron groenlandicum (Oeder) Kron & Judd, labrador-tea
  Vaccinium angustifolium Aiton, early low blueberry
  V. myrtilloides Michx., velvet-leaf blueberry

FABACEAE (Pea Family)
  Amphicarpaea bracteata (L.) Fernald, hog-peanut
  Lathyrus ochroleucus Hook., cream pea-vine
  L. venosus Muhl. ex Willd., forest pea
  **Lotus corniculatus* L., bird's-foot trefoil
  **Melilotus officinalis* (L.) Lam., yellow sweet-clover
  **Trifolium hybridum* L., alsike clover
  **T. pratense* L., red clover
  **T. repens* L., white clover
  Vicia americana Muhl. ex Willd. ssp. *americana*, American vetch

GENTIANACEAE (Gentian Family)
  Gentiana andrewsii Griseb. var. *andrewsii*, bottle gentian (1153)

GERANIACEAE (Geranium Family)
  Geranium bicknellii Britton var. *bicknellii,* Bicknell's crane's-bill

GROSSULARIACEAE (Gooseberry Family)
  Ribes americanum Mill., American black currant (1158)
  R. cynosbati L., eastern prickly gooseberry (1155)
  R. hirtellum Michx., hairy-stem gooseberry (1234)
  R. triste Pall., swamp red currant

LAMIACEAE (Mint Family)
  Agastache foeniculum (Pursh) Kuntze, fragrant giant hyssop (1197)
  Lycopus americanus Muhl. ex W.P.C.Barton, American water-horehound
  L. uniflorus Michx., northern bugleweed
  Mentha arvensis L. var. *canadensis* (L.) Kuntze, field mint (1182)
  Prunella vulgaris L. ssp. *lanceolata* (W. P. C. Barton) Hultén, heal-all
  Scutellaria galericulata L., common skullcap

S. lateriflora L., blue skullcap
Stachys palustris L., marsh hedge-nettle

LYTHRACEAE (Loosestrife Family)
**Lythrum salicaria* L., purple loosestrife

MYRSINACEAE (Myrsine Family)
Lysimachia ciliata L., fringed loosestrife
L. terrestris (L.) Britton, Sterns, & Poggenb., swamp-candles
L. thyrsiflora L. swamp loosestrife
Trientalis borealis Raf. ssp. *borealis*, American starflower

OLEACEAE (Olive Family)
Fraxinus americana L., white ash
F. nigra Marshall, black ash
F. pennsylvanica Marshall, green ash

ONAGRACEAE (Evening-primrose Family)
Epilobium angustifolium L. ssp. *circumvagum* Mosquin, fireweed
E. ciliatum Raf. ssp. *ciliatum*, American willow herb
E. coloratum Biehler, cinnamon willow-herb
E. leptophyllum Raf., American marsh willow-herb (1162)
Oenothera perennis L., small evening-primrose

OXALIDACEAE (Wood-sorrel Family)
Oxalis dillenii Jacq., southern yellow wood-sorrel
O. stricta L., tall wood-sorrel

PAPAVERACEAE (Poppy Family)
Sanguinaria canadensis L., bloodroot

POLYGONACEAE (Smartweed Family)
Persicaria amphibia (L.) Gray, water smartweed
P. sagittata (L.) H. Gross, arrow-leaved tear-thumb
**Rumex crispus* L., curly dock
R. britannica L., great water dock (1152)

RANUNCULACEAE (Buttercup Family)
Actaea rubra (Aiton) Willd., red baneberry
Anemone canadensis L., Canada anemone
A. cylindrica A.Gray, thimbleweed (1249)
A. quinquefolia L. var. *quinquefolia*, wood anemone
A. virginiana L., tall anemone
Aquilegia canadensis L., Canadian columbine
Caltha natans Pall., floating marsh-marigold
C. palustris L., marsh-marigold
Clematis virginiana L., virgin's-bower
Ranunculus abortivus L., little-leaf buttercup
**R. acris* L., common buttercup
R. hispidus Michx., bristly buttercup
R. pensylvanicus L.f., Pennsylvania buttercup (1232)
R. recurvatus Poir. var. *recurvatus*, hooked buttercup
Thalictrum dasycarpum Fisch. & Avé-Lall., tall meadow-rue
T. dioicum L., early meadow-rue

ROSACEAE (Buttercup Family)
Agrimonia gryposepala Wallr., common agrimony
Amelanchier interior Nielsen, inland juneberry (1169)
A. laevis Wiegand, Allegheny serviceberry
A. sanguinea (Pursh) DC. var. *sanguinea*, New England serviceberry
Comarum palustre L., marsh cinquefoil
Crataegus crus-galli L., cockspur hawthorn
Fragaria vesca L. ssp. *americana* (Porter) Staudt, woodland strawberry

F. virginiana Duchesne, wild strawberry
Geum aleppicum Jacq., yellow avens
G. macrophyllum Willd. var. *macrophyllum*, big-leaved avens
Potentilla norvegica L., strawberry-weed (1233)
**P. recta* L. sulphur cinquefoil
P. simplex Michx. common cinquefoil
Prunus americana Marshall, American plum
P. pensylvanica L. f., pin cherry
P. virginiana L. var. *virginiana*, chokecherry
Rosa acicularis Lindl. ssp. *sayi* (Schwein.) W. H. Lewis, bristly rose
R. blanda Aiton, smooth rose
Rubus allegheniensis Porter ex L. H. Bailey, common blackberry
R. idaeus L. var. *strigosus* (Michx.) Maxim., red raspberry
R. parviflorus Nutt., thimbleberry
R. pubescens Raf., dwarf red raspberry
Spiraea alba Du Roi var. *alba*, white meadowsweet

RUBIACEAE (Bedstraw, Madder Family)
Galium asprellum Michx., rough bedstraw
G. boreale L., northern bedstraw
G. tinctorium L., southern three-lobed bedstraw
G. trifidum L. ssp. *trifidum*, northern three-lobed bedstraw (1166)
G. triflorum Michx., fragrant bedstraw

SALICACEAE (Willow Family)
Populus balsamifera L. ssp. *balsamifera*, balsam poplar
P. grandidentata Michx., big-tooth aspen
P. tremuloides Michx., quaking aspen
Salix bebbiana Sarg., beaked willow
S. discolor Muhl., pussy willow
S. humilis Marshall, upland willow
S. interior Row., sandbar willow
S. nigra Marshall, black willow
S. petiolaris Sm., meadow willow
S. planifolia Pursh, basket willow (1184, 1276)
S. pyrifolia Andersson, balsam willow (1170, 1175, 1181)
**S. x rubens* Schrank (pro sp.), hybrid crack willow (1150, 1154)

SANTALACEAE
Comandra umbellata (L.) Nutt ssp. *umbellata*, bastard-toadflax

SAXIFRAGACEAE (Saxifrage Family)
Micranthes pensylvanica (L.) Haw., eastern swamp saxifrage

SCROPHULARIACEAE (Figwort, Snapdragon Family)
Castilleja coccinea (L.) Spreng., Indian paintbrush (1161, 1165)
Chelone glabra L., turtlehead (1156)
Gratiola neglecta Torr., clammy hedge-hyssop (1228)
Mimulus ringens L. var. *ringens*, monkey-flower
Scrophularia lanceolata Pursh, American figwort

URTICACEAE (Nettle Family)
Urtica dioica L., stinging nettle

VALERIANACEAE (Valerian Family)
**Valeriana officinalis* L., garden valerian

VIOLACEAE (Violet Family)
Viola canadensis L., Canadian white violet
V. cucullata Aiton, blue marsh violet
V. labradorica Schrank, dog violet
V. novae-angliae House, New England blue violet

V. pubescens Aiton, downy yellow violet
V. sororia Willd., door-yard violet

MONOCOTYLEDONS

ALISMATACEAE (Water-plantain Family)
Alisma triviale Pursh, northern water plantain

CYPERACEAE (Sedge Family)
Carex arctata Boott, drooping woodland sedge
C. atherodes Spreng., hairy-leaved lake sedge (1204)
C. aurea Nutt., golden sedge (1274, 1250)
C. brunnescens (Pers.) Poir. ssp. *sphaerostachya* (Tuck.) Kalela, green bog sedge (1276)
C. buxbaumii Wahlenb., Buxbaum's sedge
C. canescens L., gray bog sedge
C. castanea Wahlenb., chestnut sedge (1420)
C. crawfordii Fernald, Crawford's sedge (1248, 1262)
C. disperma Dewey, soft-leaf sedge
C. gracillima Schwein., graceful sedge
C. intumescens Rudge, greater bladder sedge
C. lacustris Willd., common lake sedge (1216)
C. lasiocarpa Ehrh. ssp. *americana* (Fernald) D. Löve & Bernard, woolly-fruit sedge (1217)
C. lupulina Willd., hop sedge (1258)
C. oligosperma Michx., few-seeded sedge
C. projecta Mack., loose-headed oval sedge
C. radiata (Wahlenb.) Small, eastern star sedge (1210)
C. retrorsa Schwein., knot-sheath sedge (1275)
C. scoparia Schkuhr ex Willd., var. *scoparia* , broom sedge (1218, 1238, 1273, 1277)
C. stipata Muhl. ex Willd., var. *stipata,* fox sedge (1271)
C. stricta Lam., tussock sedge
C. tenera Dewey, quill sedge (1251, 1272)
C. trisperma Dewey, three-seeded bog sedge (1211)
C. utriculata Boott, yellow lake sedge (1215)
C. vesicaria L., blister sedge (1278)
C. vulpinoidea Michx., brown fox sedge (1237)
Eleocharis erythropoda Steud., bald spike rush (1243, 1256)
E. intermedia(Muhl.)Schult. matted spike rush (1263, 1264, 1265)
E. nitida Fernald., neat spike rush (1193, 1221, 1224, 1256)
E. obtusa (Willd.) Schult., blunt spike rush (1204, 1259)
E. ovata (Roth) Roem. & Schult., oval spike rush (1284)
E. palustris (L.) Roem. & Schult., marsh spike rush (1257, 1267)
Eriophorum angustifolium Honck., tall cotton-grass
Schoenoplectus acutus (Muhl. ex Bigelow) A. Löve & D. Löve var. *acutus,* hard stem bulrush
S. tabernaemontani (C. C. Gmel) Palla, soft-stem bulrush
Scirpus atrocinctus Fernald., black-girdled wool-grass
S. atrovirens Willd., black bulrush
S. cyperinus (L.) Kunth., wool-grass
S. microcarpus J. Presl & C. Presl, panicled bulrush

IRIDACEAE (Iris Family)
Iris versicolor L., northern blue flag
Sisyrinchium montanum Greene, mountain blue-eyed-grass (1219)

JUNCACEAE (Rush Family)
**Juncus articulatus* L., jointed rush (1282)
J. brevicaudatus (Engelm.) Fernald, narrow-panicle rush (1254, 1281)
J. effusus L., common rush
J. nodosus L., joint rush (1151, 1201, 1203, 1244)
J. pelocarpus E. Mey., brown-fruited rush (1205)
J. tenuis Willd., path rush (1268, 1270)
J. vaseyi Engelm., Vasey's rush (1206, 1242, 1245)

Luzula acuminata Raf. var. *acuminata*, hairy wood rush
L. multiflora (Ehrh.) Lej. ssp. *multiflora*, common wood rush

LILIACEAE (Lily Family)
Clintonia borealis (Aiton) Raf., yellow blue-bead-lily
Lilium michiganense Farw., Michigan lily
Maianthemum canadense Desf., wild lily-of-the-valley
M. racemosum (L.) Link *ssp. racemosum*, false Solomon seal
M. trifolium (L.) Sloboda, false mayflower
Polygonatum pubescens (Willd.) Pursh, hairy Solomon seal
Streptopus lanceolatus (Aiton) Rev., rosy twisted-stalk
Trillium cernuum (L.) var. *cernuum* nodding trillium
Uvularia grandiflora Sm., large-flowered bellwort
U. sessilifolia L., sessile bellwort

NAJADACEAE (Naiad, Water-nymph Family)
Najas flexilis (Willd.) Rostk. & W.L.E.Schmidt, northern water-nymph (1288)

ORCHIDACEAE (Orchid Family)
Corallorhiza maculata (Raf.) Raf., spotted coralroot
Malaxis unifolia Michx., green adder's-mouth

POACEAE (Grass Family)
**Agrostis gigantea* Roth, redtop
A. hyemalis (Walter) Britton, Sterns & Poggenb., tickle grass
**Alopecurus pratensis* L., meadow foxtail
**Beckmannia syzigachne*, (Steud.) Fernald, American slough grass
Calamagrostis canadensis (Michx.) P. Beauv., blue-joint grass
Elymus hystrix L. var. *hystrix*, bottlebrush grass (1261)
E. virginicus L. var. *virginicus*, Virginia wild-rye
**Elytrigia repens* (L.) Desv. ex B.D.Jacks, quackgrass (1209)
**E. smithii* (Rydb.) Nevski, western wheat grass (1290)
Glyceria canadensis (Michx.) Trin., rattlesnake manna grass
G. grandis S. Watson, American manna grass
G. striata (Lam.) Hitchc., fowl manna grass
Leersia oryzoides (L.) Sw., rice cut grass
Oryzopsis asperifolia Michx., rough-leaved rice grass
O. pungens (Torr. ex Spreng.) Hitchc., mountain rice grass
**Phalaris arundinacea* L., reed canary grass
**Phleum pratense* L. ssp. *pratense*, timothy
**Poa annua* L., annual bluegrass
P. palustris L., marsh bluegrass
**P. pratensis* L., Kentucky bluegrass
Puccinellia pallida (Torr.) R.T.Clausen, pale false manna grass
Schizachne purpurascens (Torr.) Swallen, false melic grass

POTAMOGETONACEAE (Pondweed Family)
Potamogeton amplifolius Tuck. large-leaved pondweed (1286)
P. vaseyi J.W.Robbins, Vasey's pondweed (1289)
P. zosteriformis Fernald, flat-stemmed pondweed (1287)
Stuckenia pectinata (L.) Borner, sago pondweed

SPARGANIACEAE (Bur-reed Family)
Sparganium fluctuans (Engelm. ex Morong) B.L.Rob., floating bur reed
S. glomeratum (Beurl. ex Laest.) Neuman, northern bur reed (1202)

TYPHACEAE (Cat-tail Family)
Typha latifolia L., broad-leaved cat-tail

Denotes non-native, introduced, exotic plant species found at Pokegama SNA
Numbers in parentheses are collection numbers

NOTEWORTHY COLLECTIONS

MINNESOTA

Lonicera caerulea L. subsp. *edulis* (Turcz. ex Herder) Hultén. (Caprifoliaceae). Sweetberry honeysuckle.

Previous knowledge. Lonicera caerulea subsp. *edulis* is a deciduous shrub native to northeast Asia (Ohba 1993). In portions of its native range Hultén (1930) and Ohba (1993) described it as common in meadows and moderately shady forests. This subspecies is cultivated for its glaucous, blue, edible "berries," which are actually two fleshy ovaries that are so tightly enclosed by a fleshy cupule of bractlets that they appear to be connate over their full length (Rehder 1903); these are suitable for jam and jelly (Whealy and Demuth 1993). Also treated by some authors as a variety of *L. caerulea* or as a species, sweetberry honeysuckle has apparently not been reported as a non-cultivated member of the flora in North America or elsewhere beyond its native range (Randall 2002). Bailey (1949) asserted that *L. caerulea* was naturalized in North America, but there do not appear to be specimen collections to support this. USDA NRCS (2010) indicated an Ontario record of *L. emphyllocalyx*, recognized by some (e.g., Ohwi 1965) as an old-world variety of *L. caerulea*, but that record seems to be based on material in cultivation (L. Brouillet, personal communication, 6 April 2010).

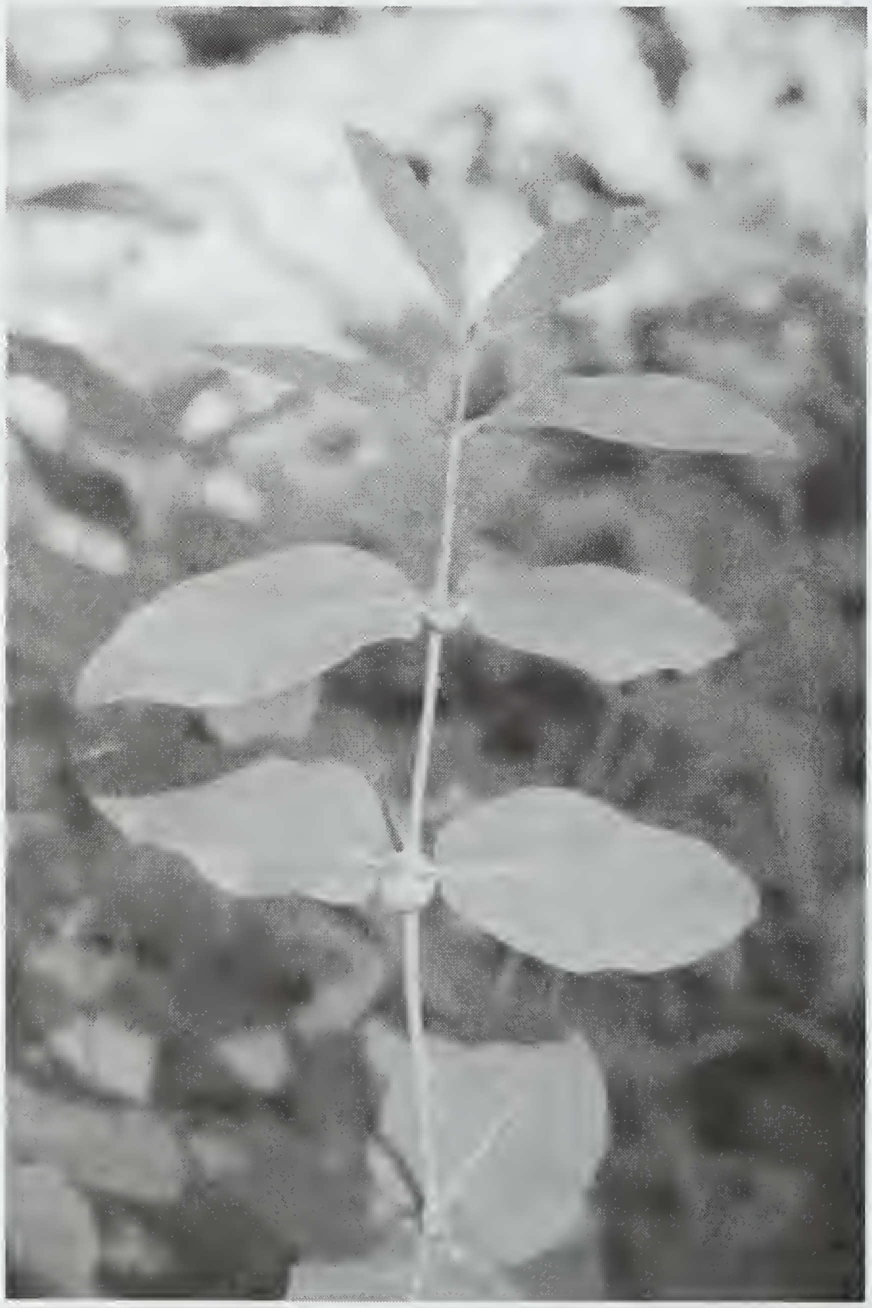

FIGURE 1. Vigorous first-year stem of *Lonicera caerulea* subsp. *edulis*, showing connate stipules and superposed lateral buds as they appear during the growing season. Photograph courtesy of Raymond G. Barnes.

Significance of the report. About 25 shrubs of *L. caerulea* subsp. *edulis* were observed in a woodland on the rural outskirts of Duluth, Minnesota, distributed irregularly within a polygon of ~125 m^2. The sweetberry

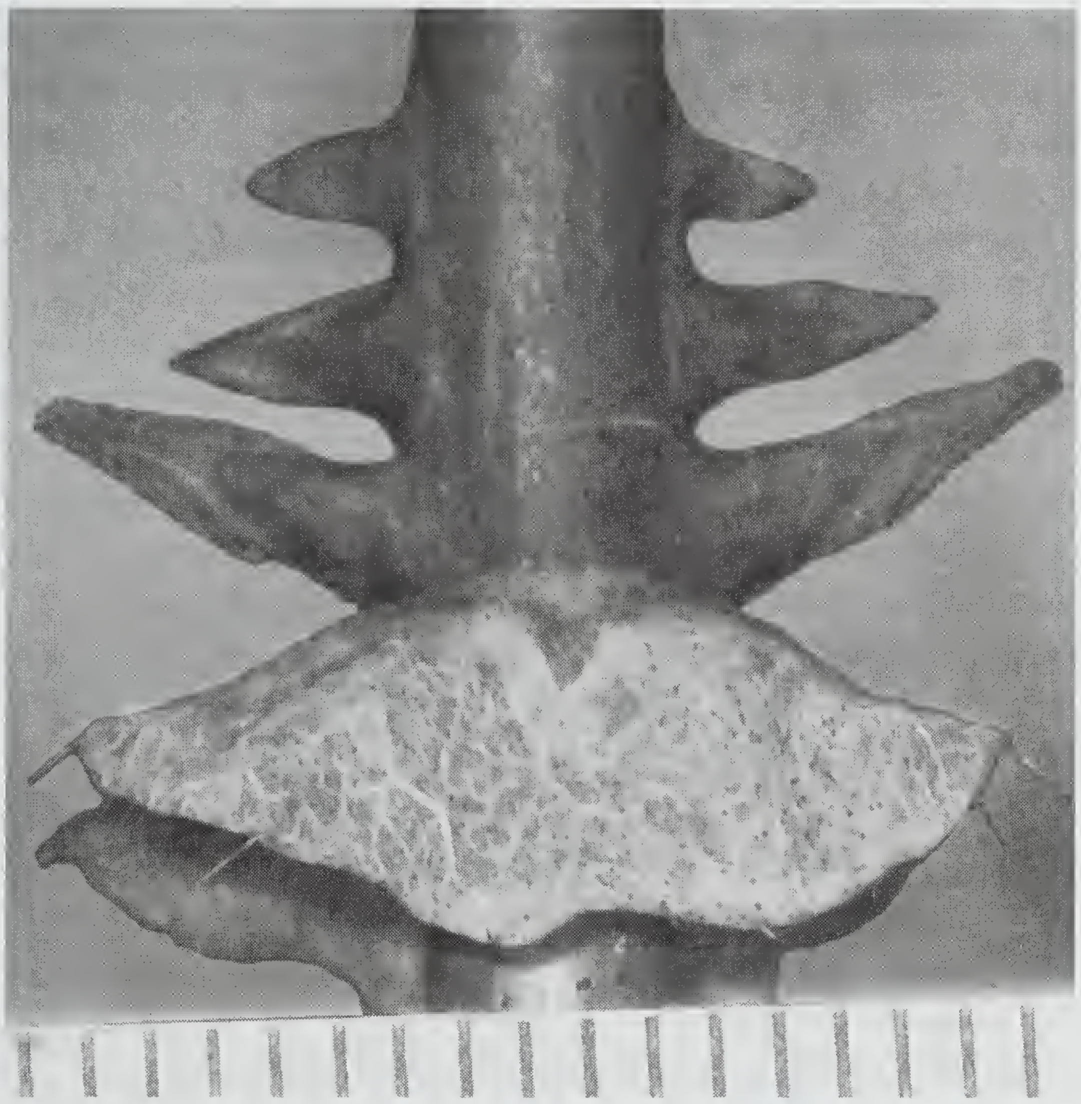

FIGURE 2. Vigorous first-year stem of *Lonicera caerulea* subsp. *edulis*, showing connate stipules and superposed lateral buds as they appear during the leafless season. The divisions on the scale at the bottom are each 1 mm long. Photograph by David J. Schimpf.

honeysuckles were up to 2 m tall, associated with *Alnus incana* subsp. *rugosa* under about 50% canopy cover from *Populus tremuloides*, *Betula papyrifera*, *Acer rubrum* and *Sorbus decora*. Almost all of the remaining woody vegetation was native, except for a few of the vertebrate-dispersed alien shrubs *Frangula alnus* and *Lonicera tatarica*. The collection site, with mesic to wet-mesic loamy soil, was about 200 m from the nearest residence, and much farther from any other homesteads. Sweetberry honeysuckle's abundant fruiting at the collection site indicates a potential to be further dispersed from it, into forested or open habitats. Sweetberry honeysuckle seems to be a relative newcomer in the North American nursery trade, as it has seldom appeared in catalogs; some commercial offerings name it "honeyberry." Bailey (1949) did not list any *Lonicera* being cultivated for edible fruit. This seems to be the first report of this taxon's occurrence outside of cultivation in North America.

Diagnostic characters. On its most vigorous twigs *L. caerulea* subsp. *edulis* grows multiple superposed accessory lateral buds that are firm, sharp and up to 5 mm long; these nodes also bear large connate stipules (Figure 1) that persist through the winter (Figure 2). These character states were described by Rehder (1903), who later (Rehder 1960) mentioned the stipules but not the extra buds. Certain other North American native and introduced species of *Lonicera* sometimes have superposed buds (Trelease 1967; Petrides 1972), but we have not found mention of persistent stipules in treatments of North American *Lonicera*. There are a few other Asian *Lonicera* species with similar stipules and buds, but not the same form and color of fruit (Rehder 1903). Ohba (1993) contrasted the European *L. caerulea* subsp. *caerulea* as having larger, narrower leaves and bitter fruit, and Hultén (1930) distinguished that subspecies by its less elongate, bitter fruit. The North American native *L. caerulea* var. *villosa* (Michx.) T. & G. has similar edible blue fruits (Fernald 1950), which are ovoid to ellipsoid (Smith 2008); it differs by lacking large stipules and by having branches with axillary angles less than 45° (Rehder 1903). In addition, the native variety is typically no more than about 1 m tall (Gleason and Cronquist 1991). The leafless twigs of *L. caerulea* subsp. *edulis* are deep reddish brown, with the vigorous twigs glabrous and lustrous and the other twigs hairy and dull. A high fraction of the spring twigs of some sweetberry honeysuckles were seen to have been browsed (presumably by white-tailed deer, *Odocoileus virginianus*) during the winter, more so than for the other woody species growing near them. These heavily browsed stems, reduced to less than ~1 m tall, did not flower. The collection date for the specimens cited as being in flower occurred during an exceptionally warm early spring; we expect that mid-May might be a more typical time for anthesis at this site.

Specimen citations. Minnesota. St. Louis Co.: Duluth, SW¼ Sec. 8, T50N R14W, approaching winter condition, 21 Oct 2008, *Pomroy and R. Barnes 2652* (DUL); fruit ripening, 24 Jul 2009, *Pomroy, R. Barnes, and Schimpf 2666, 2667* (DUL, MIN); in flower, 28 Apr 2010, *Schimpf 585* (DUL, MIN).

Lonicera ×salicifolia Dieck ex Zabel. (Caprifoliaceae). Willow-leaved honeysuckle.

Previous knowledge. The deciduous shrub *Lonicera ×salicifolia* is a spontaneous hybrid between the northeast Asian native *L. ruprechtiana* and *L. ×xylosteoides*, the latter being a hybrid between the Eurasian natives *L. tatarica* and *L. xylosteum* (Rehder 1960; Green 1966). These parent taxa have been brought close enough for interbreeding through cultivation or escape from cultivation. In North America, *L. ×salicifolia* has been reported growing outside of cultivation in apparently only one place, near Cleveland, Ohio (Wilder and McCombs 2002; USDA NRCS 2010). Its abundance and reproductive status there were not reported. Green (1966) asserted that *L. ×salicifolia* is seldom cultivated.

Significance of the report. One individual of *L. ×salicifolia* was found on a large, steeply sloping exposure of gabbroic bedrock in Duluth, Minnesota, apparently the first report for the state and second for North America. The outcrop is surrounded by natural vegetation, is elevated ~75 m (at the collection point) above a thinly settled area, and is heavily invaded by the non-native shrubs *Cotoneaster acutifolius* var. *lucidus* and *Lonicera morrowii*. The *L. ×salicifolia* shrub was about 1.5 m tall, and appeared to be vigorous. There is a very large area of similar habitat in the vicinity of the collection point, but little of it was searched for other individuals of *L. ×salicifolia* or its parent species because of hazardous rugged terrain. The habitat reported for the other North American occurrence of *L.* ×*salicifolia* was "high on ridge" (Wilder and McCombs 2002).

Diagnostic characters. The Duluth *L.* ×*salicifolia* had leaf blades up to 4 cm long by 1.5 cm wide, with rounded base, acute to acuminate apex, and pale green hairy abaxial surface. Most leaves ascended the stem, but were not appressed. Petioles and new stems were reddish, darkest at the nodes. The pedicels well exceeded the petioles, bearing pairs of axillary flowers that were only 7 mm long. The bilaterally symmetrical corollas were yellow, the calyces reddish and spreading, the bractlets obtuse and nearly as long as the ovaries, and the bracts long and subulate. Long hairs were dense on the corollas and styles, but sparser on the calyces, bractlets, bracts and peduncles; the bracts and peduncles were also thinly glandular. The ovaries were glabrous. Green (1966) reported that most flowers of *L.* ×*salicifolia* abort without producing fruit. The Duluth plant lacked functional stamens in all 20 pairs of flowers that were examined, and fewer than ten ripe fruits were seen on the whole plant at the same time that neighboring *L. morrowii* shrubs of similar size held countless ripe fruits. This suggests that *L.* ×*salicifolia* set fruit through pollen received from other Eurasian *Lonicera* nearby; the fruits were irregularly clustered on *L.* ×*salicifolia*, consistent with rare, localized pollination. Fruits of *L.* ×*salicifolia* were depressed-globose, scarlet, glossy and ~7 mm in diameter. Each fruit contained a few seeds ~2.5 mm long, whereas those of the *L. morrowii* nearby were ~3 mm long.

Specimen citations. Minnesota. St. Louis Co.: Duluth, Sec. 34, T49N R15W, in flower, 30 May 2010, *Schimpf 590* (DUL, MIN); fruit ripe 29 July 2010, *Schimpf 597* (DUL, MIN).

Vicia tetrasperma (L.) Schreber. (Fabaceae). Four-seed vetch.

Previous knowledge. Vicia tetrasperma is an annual climbing forb that is native to Eurasia and weedy in North America (Isely 1998), but not known from the central plains (USDA NRCS 2010). The species is apparently not one that is cultivated in the United States (Gunn 1971). The previous collection site nearest to Minnesota appears to be one near the Lake Michigan shore in Wisconsin (Wisflora 2010).

Significance of the report. A non-cultivated population of *V. tetrasperma* in Duluth, Minnesota appears to be the first one documented for the state. Plants of this species were very common over about 30 m^2 between a residential street and a woodland, climbing on other herbaceous species. The site had fairly well-drained loamy soil and partial sun.

Diagnostic characters. Vicia tetrasperma is distinctive within the genus in having inflorescences that each bear usually only one or two small flowers, producing pendant fruits with a broadly rounded apex (Isely 1998). The shoots are very slender in every respect, and almost completely glabrous.

Specimen citations. Minnesota. St. Louis Co.: Duluth, Sec. 15, T50N R14W, in flower and fruit, 7 Jul 2009, *Schimpf 540* (DUL, MIN).

Lathyrus sylvestris L. (Fabaceae). Everlasting pea.

Previous knowledge. Lathyrus sylvestris is a rhizomatous perennial forb that is native to Europe and climbs with tendrils (Isely 1998). Introduced for ornamental use, it now grows outside of cultivation in many parts of the United States and Canada, but not in the states and provinces of the Great Plains (USDA NRCS 2010). Occurrence of this species in Minnesota was reported by a personal communication (USDA NRCS 2010), but there does not appear to be a collection of it from Minnesota deposited at MIN or DUL.

Significance of the report. A population of *L. sylvestris* was found outside of cultivation in rural southern St. Louis County, apparently the first location in Minnesota to be represented by herbarium specimens. The species was common across a strip approximately 200 m × 7 m on a south-facing road bank adjoining a horse pasture.

Diagnostic characters. Lathyrus sylvestris is most similar to *L. latifolius*, with the former being best distinguished by its narrower (1–2 mm) stipules (Isely 1998).

Specimen citations. Minnesota. St. Louis Co.: Lakewood Township, NE¼ of NW¼ Sec. 2, T51N R13W, in flower and fruit, 12 Aug 2010, *Pomroy and R. Barnes 2735* (DUL, MIN).

Filipendula rubra (Hill) B. L. Robinson. (Rosaceae). Queen of the prairie.

Previous knowledge. Filipendula rubra is a tall perennial forb native to moist, often open, habitats in the east-central United States (Gleason and Cronquist 1991). Although Gleason and Cronquist (1991) included Minnesota in the range of the species, no specimens documenting this are held at DUL or MIN. Cultivation of *F. rubra* is undertaken for its large warm-pink inflorescence and large leaves with distinctive lobes (Bailey 1949; Snyder 1991), with subsequent escape beyond the native range. This species is known to be established outside of cultivation in several Wisconsin locations, including Douglas County in the northwest corner of the state (Wisflora 2010).

Significance of the report. A colony of *F. rubra* was found growing in moist ground at the foot of a railroad bank in Duluth, Minnesota, perhaps the first collection from outside of cultivation for the state. This species dominated the vegetation in an area of about 20 m^2, but only one shoot bore flowers or fruits. We infer that this colony is an escape from cultivation. There were no shoots disjunct from the colony, evidence that any recent enlargement of the population may have been strictly asexual; this species is rhizomatous (Gleason and Cronquist 1991).

Specimen citation. Minnesota. St. Louis Co.: Duluth, Sec. 8, T50N R13W, in flower, 31 Jul 2009, *Schimpf 563* (DUL).

Campanula persicifolia L. (Campanulaceae). Willow bellflower.

Previous knowledge. Campanula persicifolia is a perennial forb native to meadows and open woods in Europe (Fedorov 1976); it is cultivated for its flowers (Bailey 1949) and sometimes escapes to the wild in the Northeastern and Pacific Northwest floristic regions of North America (USDA NRCS 2010). Populations outside of cultivation have been documented in several locations in northern Wisconsin (Wisflora 2010). This species has not been reported from outside of cultivation in Minnesota.

Significance of the report. Two populations of *C. persicifolia* were found in woodland margins in Duluth, Minnesota, apparently the first occurrences outside of cultivation known for the state. Both populations were in settings that gave the impression of being escapes from cultivation rather than remnants of cultivation. Each population included individuals with blue corollas and others with white corollas; at each location there were 12 or more flowering shoots, plus a greater number of non-flowering shoots.

Specimen citations. Minnesota. St. Louis Co.: Duluth, Sec. 14, T50N R14W, in flower, 8 Jul 2009, *Schimpf 542* (DUL, MIN); Duluth, Sec. 15, T50N R14W, in flower, 15 Jul 2009, *Schimpf 554* (DUL, MIN).

Cerastium arvense L. subsp. *arvense*. (Caryophyllaceae). Field chickweed.

Previous knowledge. Cerastium arvense is a small perennial forb with a worldwide distribution (Morton 2005). *Cerastium arvense* subsp. *arvense* is native to western Europe and is introduced in North America, whereas *C. arvense* subsp. *strictum* is native to the Americas and the Alps (Morton 2005). The only known collection of *C. arvense* subsp. *arvense* from Minnesota was in 1938 in Duluth [*Lakela 2406* (DUL, MIN)], at a site where we have failed to find the species recently. J. K. Morton annotated the sheet at MIN in 2003: “This appears to be *C. arvense* subsp. *arvense*—the European tetraploid which grows as an introduced weed in lawns etc. in North America. Its general appearance is typical for that subspecies but its pollen size is smaller than I would expect for subsp. *arvense*.”

Significance of the report. Collections from two populations in Duluth, Minnesota that fit the macroscopic description of *C. arvense* subsp. *arvense* give evidence that this subspecies is sparingly established in the state. Both populations grew in sand on Minnesota Point, a bay-mouth bar at the southwestern tip of Lake Superior. These locations, in a generally residential district, are some 4 km and 8 km away from Lakela’s 1938 collection site. Shoots were numerous across at least 10 m^2 in each location.

Diagnostic characters. According to Morton (2005), *C. arvense* subsp. *arvense* can be distinguished from the more variable native subspecies by the former’s mat-forming, strongly rhizomatous colonies, anthocyanic flowering stems > 20 cm tall, lack of glandular hairs below the inflorescence, anthers ≥ 1 mm long and petals that change from white to brown after pollination. The last character state was not apparent in the new collections, but there were dark fungal growths on the withered petals of the fruiting stage. Morton (2005) asserted that the two subspecies are more reliably distinguished in the field than in the herbarium.

Specimen citations. Minnesota. St. Louis Co.: Duluth, thin mown turf of park-way, Sec. 12, T49N R14W, in flower, 31 May 2009, *Schimpf 505* (DUL, MIN), in fruit, 29 Jun 2009, *Schimpf 530* (DUL, MIN); Duluth, tall grass with deciduous shrubs, Sec. 35, T50N R14W, in flower, 7 Jun 2009, *Schimpf 508* (DUL, MIN), in fruit, 29 Jun 2009, *Schimpf 529* (DUL, MIN).

Daphne mezereum L. (Thymelaeaceae). February daphne.

Previous knowledge. Daphne mezereum is a deciduous shrub native to western Eurasia, where it reaches heights of 1.5–2 m (Pobedimova 1949; Webb and Ferguson 1968). It is cultivated in North America (Bailey 1949) for its fragrant early flowers and colorful fleshy fruits, the latter being poisonous to humans (Pobedimova 1949). Escape from cultivation has been documented for eastern Canada, the northeastern United States, Ohio, Alaska and Montana (USDA NRCS 2010), and in Vilas Co., Wisconsin (Wisflora 2010).

Significance of the report. Daphne mezereum was observed near a busy highway in rural Lake County, Minnesota, apparently the first report from outside of cultivation for this state. The flowering shrub was located mid-slope, on a steep southeast-facing exposure, approximately 0.2 km from Lake Superior. The shrub was about 0.5 m tall, located under the canopy of *Populus tremuloides*, *Betula papyrifera*, *Picea glauca*, and *Alnus incana* subsp. *rugosa*. There were also several shorter, non-flowering, *D. mezereum* stems all within a distance of 0.5 m of the flowering stems. At the time of collection, leaves were not yet on the surrounding trees and shrubs, although the area had an unusually early, but very dry spring. A few leaves were beginning to appear on the *D. mezereum*. The flowers were fragrant, with brilliant magenta calyces. The only other species that had showy flowers nearby on the collection date was *Anemone quinquefolia*.

Specimen citations. Minnesota. Lake Co.: Little Marais, NE¼ Sec. 20, T57N R6W, in flower, 24 April 2010, *Pomroy and R. Barnes 2718* (DUL, MIN).

Artemisia stelleriana Besser. (Asteraceae). Dusty miller.

Previous knowledge. Artemisia stelleriana is a perennial forb that is native to sandy beaches of the northwestern Pacific Ocean (Gleason and Cronquist 1991). Because of its dense silvery tomentose herbage it is used in ornamental horticulture (Bailey 1949), from which it has escaped to other sandy habitats, mostly beaches and dunes, in North America (Shultz 2006). The only known collections from Minnesota (Lakela 1965) have been made from sands at Minnesota Point, a large bay-mouth bar at the southwestern tip of Lake Superior. Elsewhere on Lake Superior this species was collected from the Keweenaw Peninsula of Michigan (Reznicek et al. 2010). From Wisconsin there is a single collection made about 100 years ago along Lake Michigan (Wisflora 2010).

Significance of the report. Eight small patches of *A. stelleriana* were found in loamy soil in narrow strips of turf along a street in Duluth, Minnesota, an apparently unusual habitat for this species. Seven patches were found on one side of a busy four-lane street, with one patch on the opposite side. The directly neighboring turf ranged from sparse to dense for these colonies, which were beneath large deciduous trees. The shoots grew low enough to tolerate mowing, and a few of the plants produced inflorescences. These plants may have spread from an ornamental planting at a park to the north. *Artemisia stelleriana* is rhizomatous (Shultz 2006), and this local spread may have been through asexual reproduction. We have seen this species on a few other curbsides with loamy soils in Duluth, but these locations were in front of residences, where deliberate planting could not be ruled out as easily.

Specimen citations. Minnesota. St. Louis Co.: Duluth, Woodland Ave., Sec. 11, T50N R14W, in flower, 30 Jun 2009, *Schimpf 533* (DUL, MIN).

Thymus pulegioides L. (Lamiaceae). Large creeping thyme.
Thymus praecox Opiz subsp. *arcticus* (Durand) Jalas. (Lamiaceae). Creeping thyme.

Previous knowledge. Thymus is a nomenclaturally complex genus of low shrubs and semi-shrubs native to Eurasia (Sell and Murrell 2009). A few taxa are cultivated for their aromatic leaves, with some used as culinary herbs (Bailey 1949). Escapes from cultivation in North America are documented for some taxa. USDA NRCS (2010) reported that *Thymus praecox* subsp. *arcticus* was widely distributed in the Great Lakes region outside of cultivation, *T. kosteletzkyanus* has been collected on Isle Royale, Michigan, in Lake Superior, and *T. pulegioides* has been reported from many points in Michigan, but not from Wisconsin or Minnesota.

Significance of the report. Collections from three Minnesota sites held at MIN, labeled as *T. serpyllum* and listed by USDA NRCS (2010) as *T. praecox* subsp. *arcticus,* can be assigned to *T. pulegioides.* Two collections in 2007, both from sunny, closely mown cemetery turf in northeastern Minnesota, are also of *T. pulegioides.* These five collection sites are well dispersed geographically, suggesting that this species may be established at other sites in the state. One collection at DUL from the Lake Superior shore of Minnesota is of *T. praecox* subsp. *arcticus*, apparently the only one known from the state. Thus there is evidence of two species of *Thymus* in the wild in Minnesota.

Diagnostic characters. Thymus pulegioides is morphologically separated from *T. praecox* subsp. *arcticus* by the location of the pubescence on the lower, quadrangular, internodes of flowering stems; hairs are concentrated on the angles in the former, but are concentrated on two opposite faces in the latter (Jalas 1972; Voss 1996). The longest leaves (including petiole) of *T. praecox* subsp. *arcticus* are 5-8 mm, whereas those of *T. pulegioides* can reach 18 mm (Jalas 1972). *Thymus kosteletzkyanus* [*T. pannonicus* in Jalas (1972) and Voss (1996)] has internodes that are terete or only weakly angular, with the hairs evenly distributed around the circumference.

Specimen citations. Thymus pulegioides—Minnesota. Beltrami Co.: Waskish, T154N R30W, leaves to 8 mm long, 22 Jul 1983, *anonymous s. n.* (MIN); Pine Co.: Willow River, sandy soil, Sec. 2, T44N R20W, leaves to 9 mm long, 3 Sep 2007, *Schimpf 447* (DUL, MIN); St. Louis Co.: Duluth, loamy soil, Sec. 2, T50N R14W, leaves to 10 mm long, 25 Aug 2007, *Schimpf 442* (DUL); St. Louis Co.:

Vermilion Dam, wooded slope, Sec.11, T63N R17W, leaves to 15 mm long, 7 Aug 1940, *O. Lakela 3956* (MIN); Washington Co: Afton Township, T28N R20W, leaves to 8 mm long, 31 Jul 1986. *J. Bender s. n.* (MIN).

Thymus praecox subsp. *arcticus* – Minnesota. Lake Co.: Beaver Bay, among rocks, T55N R8W, leaves to 5 mm long, Jul 1980, *G. Lowry s. n.*, determined as *Thymus praecox* Opiz by W. J. Dress and H. Flannery 16 Oct 1980 (DUL).

WISCONSIN

Briza media L. subsp. *media.* (Poaceae). Perennial quaking grass.

Previous knowledge. Briza media is a perennial grass native to most of Europe and the Caucasus region (Tutin 1980; Snow 2007). It has also been recorded (apparently as a native) from Syria, Turkey, Kashmir, Myanmar, Nepal and Tibet, and is introduced in South Africa, Australia and New Zealand (Dixon 2002). In North America it is widely established in New England, and has also been reported from Newfoundland, Nova Scotia, Ontario, Alabama, Colorado and California (Snow 2007; USDA NRCS 2010). It has been known from the upper Great Lakes states only from six counties in lower Michigan (Reznicek et al. 2010). Scoggan (1978) described it as a "garden escape" or "casual waif" in Canada; in addition to the above provinces, he included two sites on Vancouver Island, British Columbia.

In its native range *B. media* is typically a plant of well-drained, nutrient-poor calcareous soils (Dixon 2002). It tolerates a wide variety of edaphic conditions, though, having been recorded from sites ranging from poorly drained to dry, on soils with a wide variety of textures and with pH ranging from 4.0 to 8.0 (Dixon 2002). *Briza media* survives grazing, mowing, trampling, fire and light shade (Dixon 2002). It is a poor competitor with taller vegetation (Grime et al. 1988; McLellan et al. 1997), persisting but generally not flowering in 50% shade (Dixon 2002). *Briza media* forms only a transient seed bank (Grime et al. 1988). The seeds are readily transported on the wool of sheep (Fischer et al. 1996), and might be moved by other large animals. It is cultivated for its downward-arching, trembling, ornamental spikelets, which are used fresh or dried in flower arrangements (Everett 1981; Brickell and Zuk 1996). Scoggan (1978) used the name "doddering dillies" for this species.

Significance of the report. In 2009 five flowering patches of *B. media* were found along a section of the former United States Navy Extremely Low Frequency (ELF) transmission corridor in northern Wisconsin. In 2010 seven more patches were found along this corridor, six to the east and one to the west of the 2009 patches. The known population is rather evenly scattered for ~2.9 km along the corridor, from just west of Forest Road 173 eastward almost to County Road GG, entirely within the Chequamegon-Nicolet National Forest. The 25-m wide corridor traverses a gently undulating landscape of wetlands and low hills. Due to the sandy soil, the hills are well-drained and presumably somewhat droughty. All of the patches of *B. media* found were on these hills, where the vegetation tended to be relatively sparse. This habitat seems consistent with the typical habitat of *B. media* in its native range. It seems likely that this species, otherwise unknown from Wisconsin, was introduced on logging or construction equipment, as there are no residences nearby that could have served as a local source from cultivation after the corridor was built.

The section of ELF corridor where *Briza media* was found appears to be reverting to natural vegetation at varying rates: dense stands of *Salix* spp. and *Alnus incana* subsp. *rugosa* already dominate some wet areas, whereas upland areas often remain only sparsely colonized by woody vegetation, including *Salix humilis* and tree saplings. Unless this species spreads beyond this corridor, it may eventually be extirpated by the encroaching vegetation.

Diagnostic characters. With its basally disposed leaves and panicles of broad, flattened, dangling spikelets, *B. media* is a distinctive-looking grass. It may be distinguished from *B. maxima* and *B. minor*, its two congeners introduced to North America, by its perennial habit and ligules less than 1 mm long (Snow 2007). Based on their shorter stature, narrower leaves, and wide-spreading panicle branches (Tutin 1980), the Wisconsin plants appear to be subspecies *media*.

Specimen citations. Wisconsin. Ashland Co.: Shanagolden Township, NE¼ of SE¼ Sec. 30, T42N R04W, ripening seed, 24 Jul 2009, *Garske 758* (UWSP, WIS); Shanagolden Township, NW¼ of SW¼ Sec. 29, T42N, R04W, ripe seed, 25 Aug 2009, *Garske 765* (DUL, OSH); Shanagolden Township, SE¼ of NE¼ Sec. 29, T42N R04W, ripening seed, 8 July 2010, *Garske 791* (UWSP, WIS).

Campanula cervicaria L. (Campanulaceae). Bristly bellflower.

Previous knowledge. Campanula cervicaria is a biennial or short-lived monocarpic perennial forb native to Eurasia, where it is rare over at least the northern part of its European range (Eisto et al. 2000). It was first collected outside of cultivation in North America in northeastern Minnesota by O. Lakela in the 1940s (Schimpf 2005). These and subsequent collections from surrounding lands were originally misidentified as *Campanula glomerata* (Schimpf 2005). Schimpf's (2005) examination of herbarium sheets labeled as *C. glomerata* from across North America revealed no *C. cervicaria* other than those from northeastern Minnesota. In parts of northeastern Minnesota, *C. cervicaria* can be locally common (Schimpf 2005).

Often (1999) found that as *C. cervicaria* senesces in the fall, its capsule pores open and the ripe seeds fall out, with most seeds retained by bracts just below the capsule. The stems often remain standing for a year after death (Schimpf 2005), during which time strong winds liberate the seeds from the bracts (Often 1999). Often (1999) found that in Norway 60% of the seeds captured by the bracts had dispersed within three months, and only 5% remained on dead stems after one year. Based on germination experiments using soil samples from within dense stands of *C. cervicaria*, Often (1999) concluded that *C. cervicaria* forms only a sparse soil seed bank.

Significance of the report. A single flowering *C. cervicaria* plant was collected in the former United States Navy Extremely Low Frequency (ELF) transmission corridor (described under *Briza media* above), apparently the first record for Wisconsin. This plant was 8 dm tall. One other, much smaller, flowering individual was noted and photographed earlier the same day, about 0.6 km east of the first plant along the same corridor. A subsequent visit to the area turned up no additional plants. Like *B. media*, *C. cervicaria* is a grassland species with little shade tolerance, and population size is decreased by encroaching vegetation (Eisto et al. 2000).

At this point it is unclear whether *C. cervicaria* is truly established along this corridor, whether more *C. cervicaria* plants occur on unsearched portions of the corridor, or whether the existing population is on the verge of dying out. Populations with five plants or fewer, none that fruited during one year, have been observed to increase in subsequent years (Eisto et al. 2000). More field work will be necessary to determine whether *C. cervicaria* is a transient in the flora or is becoming naturalized in Wisconsin.

Diagnostic characters. Of the *Campanula* species (native and introduced) found in eastern North America, *C. cervicaria* probably most closely resembles the introduced Eurasian polycarpic perennial *C. glomerata*. It differs from *C. glomerata* by having a thicker taproot that, in North American material, typically reaches 8 mm or more wide (pressed) at the time of flowering (Schimpf 2005). The calyx lobes of *C. cervicaria* are usually 2-4 mm long and wide, and obtuse or weakly angular, versus 2 mm wide at the base, 6-12 mm long, and acute to acuminate in *C. glomerata* (Schimpf 2005). The leaves of *C. cervicaria* typically taper to a winged petiole, whereas those of *C. glomerata* are truncate or cordate at the base, with wingless petioles (Fedorov 1976). *Campanula cervicaria* frequently reaches a height of 10-13 dm in northeastern Minnesota (Schimpf 2005), whereas *C. glomerata* may reach 3-7 dm tall (Gleason and Cronquist 1991).

Specimen citation. Wisconsin. Ashland Co.: Shanagolden Township, NE¼ of SE¼ Sec. 30, T42N R04W, in flower, 8 July 2010, *Garske 792* (UWSP).

Syringa reticulata (Blume) H. Hara subsp. *reticulata.* (Oleaceae). Japanese tree lilac.

Previous knowledge. Syringa reticulata subsp. *reticulata* is a small deciduous tree native to Japan that was recently found spreading from ornamental cultivation into deciduous forest in Duluth, Minnesota (Schimpf et al. 2009). This species has not previously been reported outside of cultivation in Wisconsin or elsewhere in the western Great Lakes region, but is known from some northeastern states (USDA NRCS 2010).

Significance of the report. Non-cultivated fruiting *S. reticulata* subsp. *reticulata* trees were found on the edge of a small wooded tract in a residential area just south of the city of Superior, Wisconsin, apparently the state's first record of spread from cultivation for this taxon. Two young trees bearing capsules were growing near a roadside ditch on clay soil. The putative parent, a much larger tree, was a few meters away, in the same moist habitat, but farther from the ditch. It was likely planted many years ago. The site also included non-reproducing saplings of *S. reticulata* subsp. *reticulata*, as well as several other non-native ornamental species that had evidently been abandoned from cultivation.

Specimen citations. Wisconsin. Douglas Co.: Village of Superior, Sec. 10, T48N R14W, in fruit, 25 Sep 2009, *Schimpf 582* (DUL, WIS).

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IN MEMORIAM—FREDERICK W. CASE, JR.

With deep sadness, we note the passing of one of our most eminent members, Fred Case on Jan. 12, 2011, at age 83 years.

Fred Case was a dedicated teacher, who inspired students to study plants. He taught biology and natural science at Arthur Hill High School in Saginaw, Michigan, and gained a number of honors, including Outstanding Biology Teacher in Michigan in 1971 and Outstanding Science teacher in 1987. He also started a number of students on botanical and horticultural careers. Besides being a teacher, Fred was active his entire life in conservation, serving on the Board of Trustees of the Nature Conservancy of Michigan, and was a long time member of the advisory committee for Michigan's Threatened and Endangered Species law, and a strong supporter of the Michigan Nature Association. In recognition of his teaching and outreach efforts, the American Society of Plant Taxonomists gave Fred the prestigious Peter Raven Award in 2003. This award is "to a plant systematist who has made exceptional efforts at outreach to non-scientists."

In the summers, in addition to working in his wonderful garden, Fred also loved seeing plants in nature, and spent as much time as he could studying orchids, trilliums, pitcher plants, alpines, and anything else that interested him in the wild, including butterflies and moths, which were another great love. Fred was a great photographer and a superb speaker, much in demand internationally. His lectures were diverse but especially focused on wildflowers, trilliums, orchids, western American alpines, woodland plants, and bog plants. They always generated enthusiasm, were filled with original information, and never too short. He was always willing to speak to the Michigan Botanical Club and spoke at several Spring Forays, always skillfully using two projectors.

We owe to Fred a number of highly regarded books all of which contain information relevant to Michigan Botany. His first and probably best known book was Orchids of the Western Great Lake Region, first published in 1964, with a revised edition in 1987. Many beginning botanists, starting out with an interest in orchids, like myself, learned field botany and plant hunting using this book. In 1978, we saw Wildflowers of the Northeastern States, in the Wildflowers of the United States Color Slide Series from the New York Botanical Gardens. The text was accompanied by 35 mm slides, and this is now somewhat of a collectors item. Wildflowers of the Western Great Lakes Region (1999), with James R. Wells and T. Lawrence Mellichamp, was a more complete and modern rendition. This is a beautiful book with numerous, high quality photos. Finally, his 1997 book Trilliums, co-authored with his wife Roberta Burckhardt ("Boots") Case who passed away in 1998, was an instant classic. All his books included much horticultural as well as botanical information. He had been a research associate with the Cranbrook Institute of Science, The University of Michigan Matthaei Botanical Gardens, and the University of Michigan Herbarium. He also made significant contributions to the Michigan Flora project, especially with many hundreds of important herbarium specimens.

Fred, often with Roberta, wrote a number of scientific articles naming species and important variants in Orchids, Trilliums, and Pitcher Plants, including two Michigan Orchids *Listera ×veltmanii* Case (Type locality: Alger Co.) *Platanthera ×vossii* Case (Type Locality: Otsego Co.), The Pitcher Plants *Sarracenia ×ahlesii* Bell & Case, the federally (US) endangered Cane-brake Pitcher Plant, *S. alabamensis* Case & R. B. Case, *S. ×gilpinii* Bell & Case, and *S. rosea* Naczi, Case, & R. B. Case, and *Trillium ovatum* f. *maculosum* Case & R. B. Case. Named in Fred's honor are *Spiranthes casei* Catling & Cruise, a native Orchid of the Great Lakes region east to Nova Scotia, and *Sarracenia ×casei* Mellich., a hybrid pitcher plant. Other notable scientific contributions were the treatments of *Trillium* and of *Sarracenia* (with T. Lawrence Mellichamp) in the Flora North America series.

Fred published a number of articles in the Michigan Botanist on Michigan and Great lakes Region botany, as listed below:

Case, F. W. Jr., 1964. A Hybrid Twayblade and its Rarer Parent, *Listera auriculata*, in Northern Michigan. Michigan Bot. 3: 67–70.

Case, F. W. Jr., 1965. Discovery of the Northern Twayblade, *Listera borealis*, in the Lake Superior Region of Ontario. Michigan Bot. 4: 118–121.

Case, F. W. Jr., & W. Schwab. 1971. *Isotria medioloides*, the Smaller Whorled Pogonia, in Michigan. Michigan Bot. 10: 39–43.

Well, J. R., F. W. Case, Jr. & T. L. Mellichamp. 1976. Perfecting Wildflower Photography. Michigan Bot. 15: 183–190.

Wagner, W. H., E. G. Voss, J. H. Beaman, E. A. Bourdo, F. W. Case, J. A. Churchill, & P. W. Thompson. 1977. Endangered, Threatened, and Rare Vascular Plants in Michigan. Michigan Bot. 16: 99–122.

Case, F. W. Jr., 1982. The Snow Trillium, *Trillium nivale*, in Michigan. Michigan Bot. 21: 39–44.

Case, F. W. Jr., & P. M. Catling. 1983. The Genus *Spiranthes* in Michigan. Michigan Bot. 22: 79–92.

Case, F. W. Jr., 1983. *Platanthera ×vossii*, A New Natural Hybrid Orchid from Northern Lower Michigan. Michigan Bot. 22: 141–144.

In honor of his life-long contributions to the Michigan Botanical club, starting with being a founding student member of the Club in 1941, The Michigan Botanical Club gave Fred its Lifetime Achievement Award in 2010.

So many Botanical Club members remember Fred for his mentoring and kindness to beginning botanists, his willingness to open his magnificent garden to tours and individual visitors, and his generosity with his knowledge of all things natural. We will miss him greatly.

Survivors include a son and daughter-in-law, David B. and Sheri Leaman Case and three granddaughters. Friends planning an expression of sympathy may wish to consider the Nature Conservancy of Alabama, Roberta Case-Pine Hill Reserve, the Michigan Nature Association, the Children's Zoo at Celebration Square, or the charity of their choice.

A.A. Reznicek

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2. For noteworthy collections, manuscripts should be formatted as described in *The Michigan Botanist*, volume 27(3) p. 90. A brief description of the formatting follows. The following title, "Noteworthy collections", should begin each submitted manuscript followed on the next line by the State or Province for the species reported. The next line should list the taxon of interest using the following format: *Species* Author(s) (Family). Common name. The rest of the manuscript should include the following named sections: Previous knowledge, Significance of the report, Diagnostic characters (if desired), Specimen citations, and Literature cited. Each of these sections are largely self explanatory; however, "specimen citations" should include the relevant label data from the voucher specimen(s) including location data, collector(s), collection number, etc. Also please include which herbarium the specimen(s) is deposited in using the Index Herbariorum acronym. The manuscript should end with the name and address of the author(s).

3. Letters to the Editor can be formatted as general text without the specific sections listed above. However, literature cited and any tables or figures should be formatted as described below.

4. Please create tables using either a tab delimited format or a spreadsheet using Excel or other similar program. Each table is to be submitted as a separate file. Table captions should be placed at the top of the table. Any footnotes should appear at the bottom of the table. Please do not insert tables within the body of the text.

5. Send each figure as a separate file in a high-resolution format—eps, jpg, or tif. Figures like bar graphs that gain their meaning with color won't work—use coarse-grained cross-hatching, etc. Create figure legends as a separate text file, and the typesetter will insert them as appropriate. Please do not insert the figure in the body of the text file.

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8. Italicize all scientific names. Voucher specimens must be cited for floristic works or any other relevant study. Papers citing plant records without documenting vouchers are generally not acceptable.

9. Manuscripts may be submitted electronically to the email address of the editor. Printed versions of manuscripts may also be submitted in which case three copies should be provided. All manuscripts will be reviewed by at least two referees. A more complete set of instructions is available at http://www.michbot.org/publications/Botanist/instruct_authors.htm.

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On the cover: Fred Case, internationally-recognized botanist, award-winning teacher and long-time member of The Michigan Botanical Club passed away early in 2011. See page 39–40 for details regarding his illustrious career. Photo taken by John Freudenstein in Utah in 2004.

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April–June, 2011

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ANNOTATED CHECKLIST OF THE FLORA OF THE KALAMAZOO NATURE CENTER WITH NATURAL COMMUNITY DESCRIPTIONS

Tyler Bassett

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ABSTRACT

The need to manage several hundred acres of contiguous upland and wetland habitats requires a comprehensive understanding of individual natural features found in those habitats and their relationships across the landscape. Although the 1,200-acre (500-hectare) Kalamazoo Nature Center (KNC), in Kalamazoo County, MI has a rich history of avian research, a systematic inventory of all the natural features on the property has never been conducted. This paper describes the results of a comprehensive floristic inventory conducted during 2003–2004 within the context of a broader biological inventory. The checklist includes 702 vascular plant species and varieties and subspecies in 114 families, including 153 species and infra-specific taxa newly documented at KNC, five state-listed species, and three Kalamazoo County records. Natural communities were delineated and are described in detail and analyzed with the Floristic Quality Assessment. KNC supports six natural communities, including 459 acres (186 hectares) of mesic southern forest, 124 acres (50 hectares) of southern floodplain forest along the Kalamazoo River, and several high-quality southern wet meadows. Opportunities and challenges for managing the biodiversity supported at KNC are discussed, such as invasive species and the impacts of human activities on the natural landscape. The results of the inventory are actively used to guide the management of natural communities at KNC.

KEYWORDS: Kalamazoo Nature Center, beech-maple forest, landscape context, natural lands management

INTRODUCTION

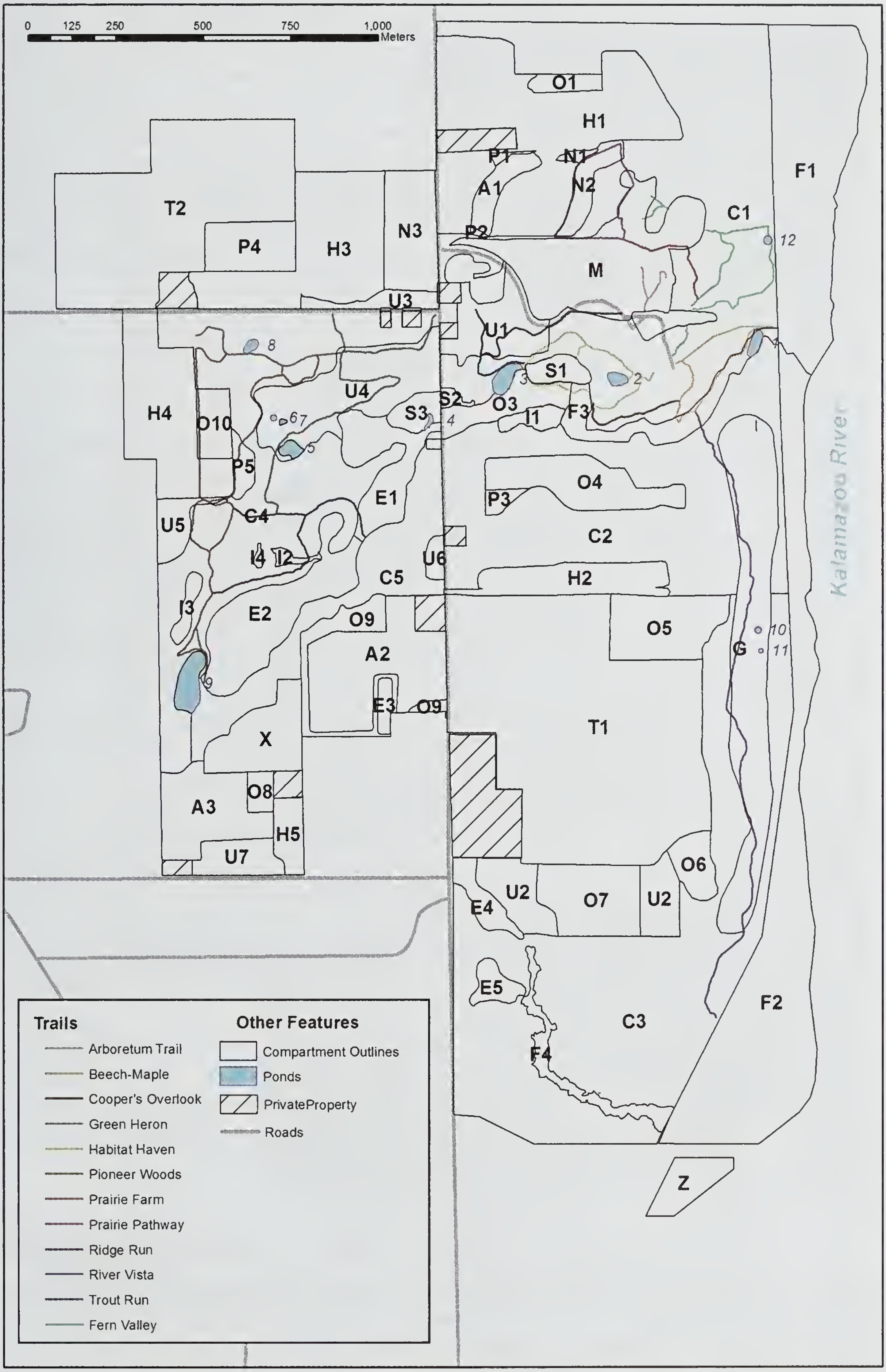
The Kalamazoo Nature Center (KNC) occupies approximately 1,200 acres (500 hectares) in an area historically dominated by beech-maple forest (Hodler et al. 1981, Comer et al. 1995). It is located in sections 21, 22, 27, 28 and 34 of Cooper Township (T1S R11W) in Kalamazoo County (42.37°N 85.58°W). KNC was established in 1960 as an outdoor environmental education center and is known for its avian research (e.g., Brewer et al. 1991). Most other animal groups as well as the vegetation of the property have been surveyed at various intensities since that time. A systematic inventory of all natural features on the property, however, has never been done. This paper presents the results of a comprehensive floristic inventory of KNC that occurred as part of a broader biological inventory. The results are presented within the context of managing the land for all biota and interesting landscape features.

A two-year biological inventory was initiated in April 2003. Vascular plants, birds, mammals, reptiles, amphibians, aquatic insects, dragonflies, butterflies, and mollusks were covered during the biological inventory. An inventory of KNC's bryophytes was also completed during that time (Ehrle 2005). While management activities such as invasive species control and prescribed fire have

TABLE 1. Natural community or land cover type, acreage, number of species, and floristic quality index for survey compartments. FQIs above 35 are shown in bold.

See Figure 1 for survey compartment locations. FQI = Floristic Quality Index (see text).

Compartment	Acres	No. of species	FQI	Area Name or Habitat Description
A1	4.19	42	9.6	hybrid poplar
A2	24.14	29	9.3	hybrid poplar
A3	15.07	55	10.5	hybrid poplar
C1	122.42	212	**54.7**	Cooper's Glen (beech-maple forest)
C2	76.62	138	**43**	Cooper's Glen (beech-maple forest)
C3	128.38	155	**47.3**	South Property (beech-maple forest)
C4	104.06	217	**49.1**	Pioneer Woods (beech-maple forest)
C5	27.89	99	30.2	disturbed beech-maple forest
E1	11.89	63	**37.4**	Source Marsh (East)
E2	20.21	95	**47.1**	Source Marsh (West)
E3	1.53	30	17.5	sedge meadow (calcareous seep)
E4	4.02	32	13.4	sedge meadow (calcareous seep)
E5	3	48	21.1	sedge meadow (calcareous seep)
F1	47.92	192	**62.1**	Kalamazoo River Floodplain (North)
F2	70.49	172	**57.4**	Kalamazoo River Floodplain (South)
F3	9.38	74	**41.3**	Trout Run Floodplain (through Cooper's Glen)
F4	5.84	51	30.5	South Stream Floodplain
G	37.98	64	20.1	Gravel Pit
I1	2.31	46	25.1	inundated shrub swamp
I2	0.83	46	24.9	inundated shrub swamp
I3	1.91	40	24.7	inundated shrub swamp
I4	0.3	22	18.8	inundated shrub swamp
O1	2.49	25	5	old-field
O3	6.94	56	23.5	old-field
O4	14.16	61	9.5	old-field
O5	13.97	40	7.6	old-field
O6	4.8	28	9.8	old-field
O7	13.82	56	11.1	old-field
O9	8.04	9	3.3	old-field
O10	4.81	34	4.1	old-field
P1	0.44	26	5.3	conifer plantation
P2	0.18	6	1.2	conifer plantation
P3	1.43	5	4.9	conifer plantation
P4	9.02	28	12.5	conifer plantation
P5	2.29	24	10	conifer plantation
RR	n/a	47	19.5	railroad
S1	2.95	115	**41.7**	East Fen
S2	0.8	51	33.5	sedge meadow
S3	3.21	79	**35.3**	West Fen
U1	11.63	59	12.5	upland shrub
U2	13.44	54	13.2	upland shrub (and Catalpa stand)
U3	3.6	48	12	upland shrub
U4	23.16	124	18.7	upland shrub (and sand mine)
U5	4.3	32	8.7	upland shrub
U7	5.86	84	17.5	upland shrub
Z	5.79	7	14.7	Kalamazoo River Floodplain (Southeast Portion)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C3
F4
Z
Trails
Arboretum Trail
Beech-Maple
Cooper's Overlook
Green Heron
Habitat Haven
Pioneer Woods
Prairie Farm
Prairie Pathway
Ridge Run
River Vista
Trout Run
Fern Valley
Other Features
Compartment Outlines
Ponds
PrivateProperty
Roads

FIGURE 1. Survey compartments delineated by natural community boundaries. See Table 1 for description, acreage, number of species, and floristic quality indices. Ponds are numbered in blue. *Map by Rob Klein, KNC (modified by Mark Miller and Jennifer Baldy, KNC).*

been ongoing at KNC, they have never been coordinated under a single vision. The biological inventory also culminated in an adaptable land management plan to guide activities on the grounds over the next 20 years. Particular attention was given to the following: 1) high quality natural communities, especially the beech-maple and floodplain forests and wetland complexes, 2) documenting rare and protected species and notable invasive species, and 3) the potential for managing the diversity of habitats at KNC within the context of the regional and local landscape. The property is divided into alpha-numeric habitat compartments that are referenced throughout this paper, and can be found on the inventory field map (Figure 1, Table 1).

HISTORY

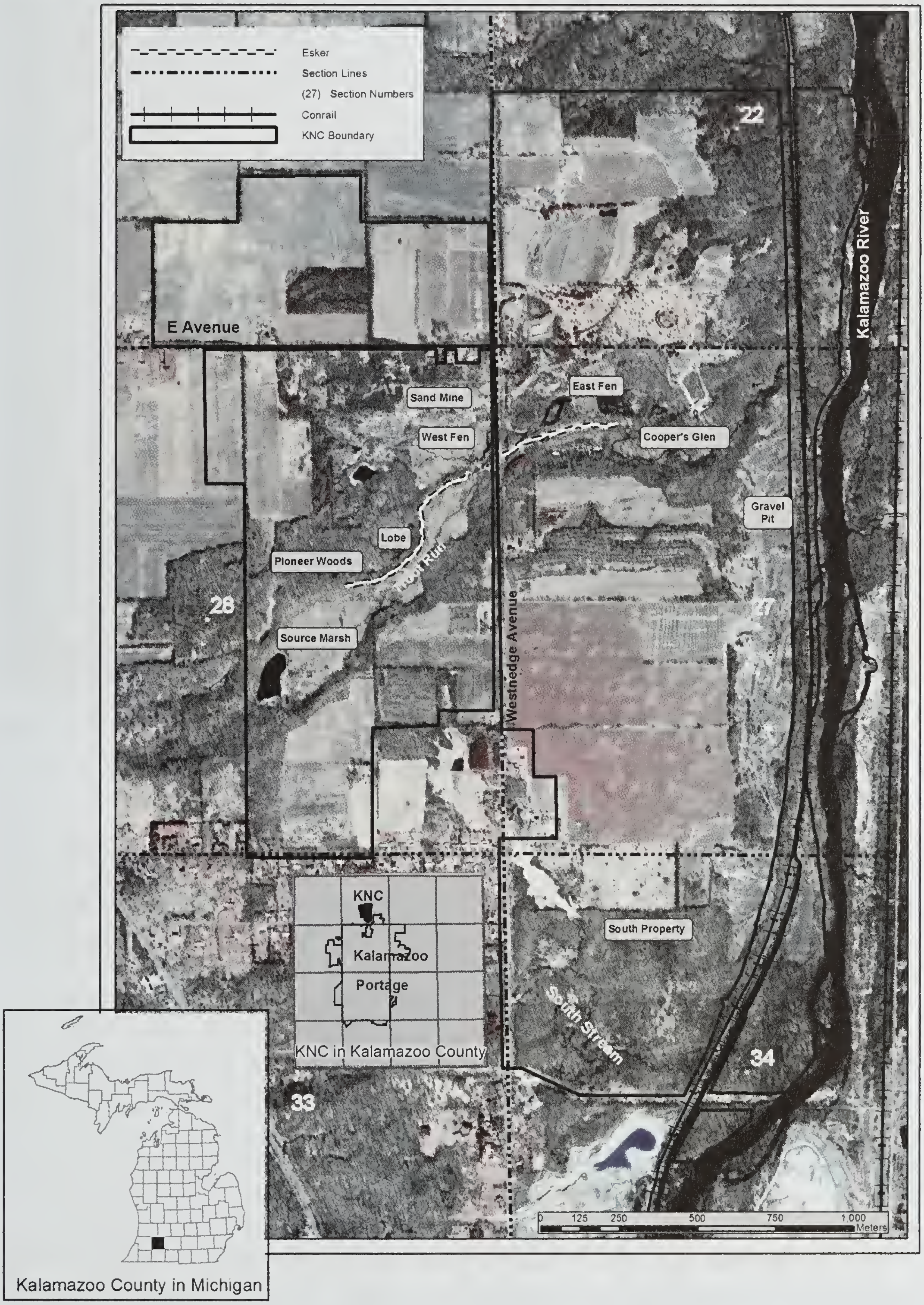
According to a history of Cooper Township included in the Kalamazoo County Directory (Thomas 1869), the river valley averaged about one mile in width and, in the south part of the township (where KNC is located), it was “swampy and timbered.” Areas bordering the river valley were hilly. Although most of the riverbed was covered with sand, pebbles and gravel, it consisted in some parts of calcareous tufa, described as a “soft porous carbonate of lime.” The 1873 plat map notes a spring and marl bed just west of the present railway line along what is now known as Trout Run (at that time called Collier Brook) (Figure 2).

The first record of settlement by Europeans on the land that is now KNC was in 1835 (United States Bureau of Land Management 2004). According to the records, farming was the primary activity on these sites. Apparently there were some difficulties with illness among Cooper Township’s farming families. Durant (1880) states that “the clearing of the land and the upturning of the soil necessarily superinduced many cases of fever, most of them being of a bilious character.”

Cooper’s Glen was a popular picnicking spot since at least the early 1900s and was well know for its flora (Hanes and Hanes 1947) and bird migrations by at least the late 1950s. It was then that a gravel operation was proposed within Cooper’s Glen. A group of concerned community members, led by Kalamazoo College professor H. Lewis Batts, Jr., organized to purchase the land and form KNC. While the initial acquisition of Cooper’s Glen was of 85 acres (Figure 3), the current KNC land-holdings in Cooper Township have been assembled gradually by acquisition of over 30 parcels, and now total almost 1,200 acres. A major goal of these land acquisitions was the protection of the whole Trout Run watershed (Figure 2).

Historical and Current Land Cover and Land Use

The pre-European settlement vegetation of the area now encompassed by KNC is described as beech-maple forest and, along the Kalamazoo River, hardwood swamp (Hodler et al. 1981; Comer et al. 1995). The 1826 and 1827 General Land Office (GLO) survey notes a diversity of trees, including beech, sugar maple, basswood, white and blue ash, elm, and ironwood (Mullett 1827). Current land cover includes significant acreages of both beech-maple (Cooper’s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Pioneer Woods
Trout Run
28
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Westnedge Avenue
Source Marsh
South Property
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KNC in Kalamazoo County
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Kalamazoo County in Michigan

FIGURE 2. Notable natural features of the Kalamazoo Nature Center. *Aerial photograph: Michigan DNR, 1998.*

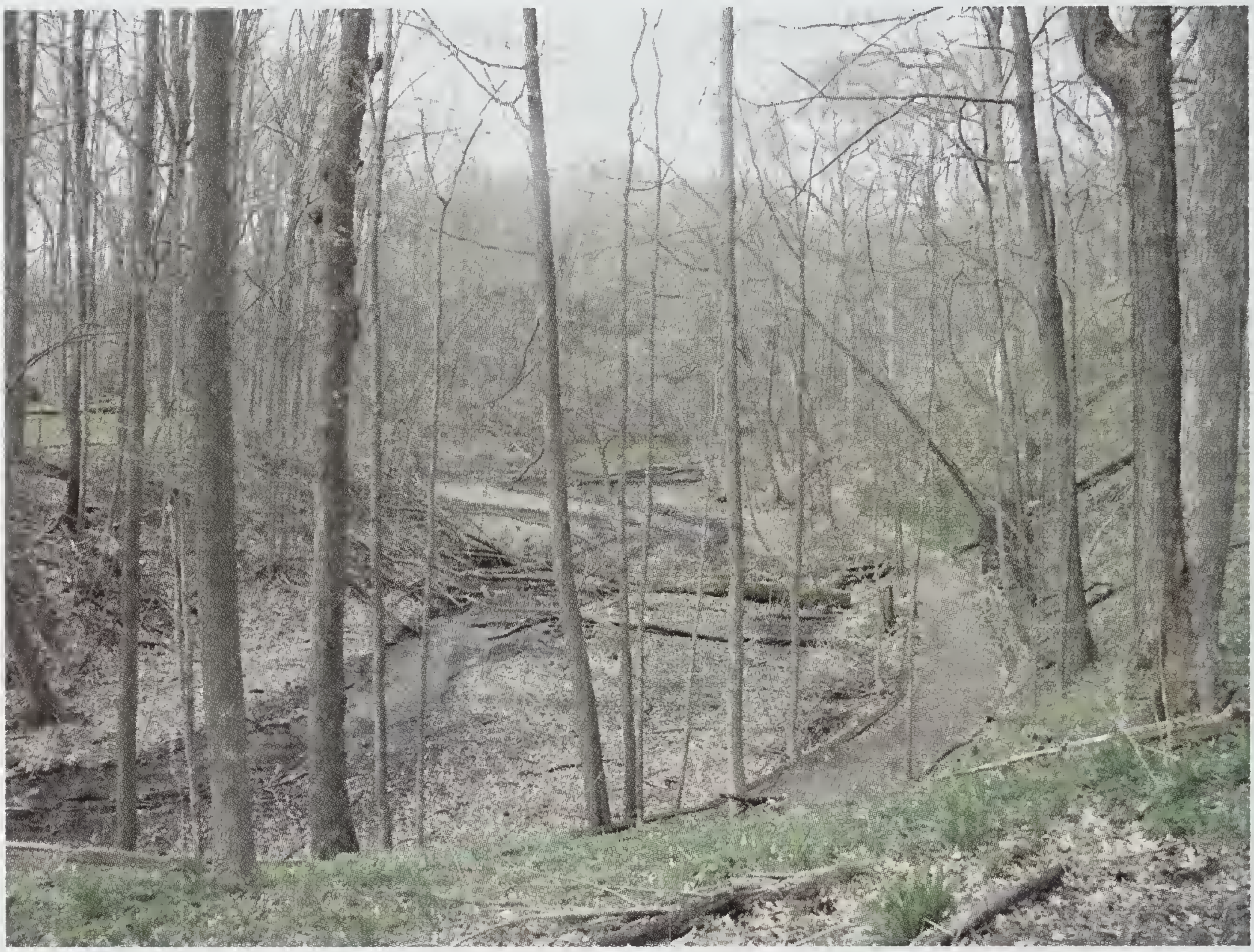

FIGURE 3. Cooper's Glen (C1), the original 85-acre tract obtained by the Kalamazoo Nature Center in 1961, showing Trout Run and narrow floodplain (F3).

Glen, Pioneer Woods) and floodplain forest (most river frontage), as well as various wetland complexes containing wet meadow, emergent marsh, shrub-carr and other wetland types (Table 1). Many disturbed land cover types are present, supporting their own unique suites of species. They include old-field, hay field, gravel pit and urban land cover.

Knowledge of the land-use history of a site is necessary to understand current plant community dynamics and future succession (Kettle et al. 2000). The majority of KNC has been disturbed through logging, tillage, grazing, and/or mineral extraction over the last 170 years. Numerous invasive plant species have proliferated on the grounds. Some, such as *Elaeagnus umbellata* (autumn olive) and *Rosa multiflora* (multiflora rose), were planted intentionally for soil conservation and wildlife benefits (R. Adams, pers. comm.). Others occupy a niche created in part by anthropogenic disturbance and have proliferated widely thereafter. Gravel and sand extraction (G and U4, respectively, in Figure 1) has occurred on the property and these areas are visibly the most disturbed. This has resulted in some microhabitats unique to the property, including some chalky gravel ponds. These areas are mostly devoid of topsoil and are filling in with trees and other vegetation very slowly; invasive and other exotic plants are dominant. The South Property (mainly C3 and parts of G) was used for many years by the previous owners as a range for running all-terrain vehicles. It is possible that an occasional ATV enthusiast still uses this portion of KNC property for that purpose, as tracks were evident crossing the South Stream during one visit in late summer 2003. The adjacent rail road cuts across a number of seeps and streams and divides important forested habitat, creating additional edge (Figure 2). Most forested tracts on the grounds (including some of the higher quality forest) contain old fences and piles of field stone that mark the margins of old agricultural fields. Some old fence lines on the property that may mark former property boundaries may also indicate old livestock enclosures and consequently historical pressures on vegetation. One fence line cuts across Source Marsh (E2), running from the forest on one side (C4) to the forest on the other (C5), suggesting both forest and wetland herbs in these areas have been impacted. It is reasonable to assume that some species have been extirpated.

PHYSICAL DESCRIPTION

Elevation

Elevation at KNC varies from 225 meters where Trout Run drains into the Kalamazoo River (Figure 2), to nearly 300 meters (Passero et al. 1978).

Climate

Climatic patterns are influenced in winter primarily by the cold continental polar and mild Pacific air masses, both of which have low total water vapor content providing for dry winters (Eichenlaub et al. 1990). In summer, tropical air masses from the Gulf of Mexico and the Caribbean Sea, both humid, become more frequent. Lake Michigan has a major effect in moderating climate, even as far inland as Kalamazoo (Eichenlaub et al. 1990). The “lake effect” moderates temperature, increases precipitation in later summer and into winter, decreases precipitation in spring and early summer, and alters wind patterns.

Typical climatic conditions in Kalamazoo County are as follows, as monitored at Michigan State University’s Kellog Biological Station at Gull Lake, 1971–2000 (ca. 11 miles to the east-northeast of KNC): mean annual minimum/maximum temperature—4.00/15.67°C, median growing season—159 days, mean precipitation—98.58 cm, mean snowfall—148.1 cm (Midwest Regional Climate Center 2009).

Geology and Soils

As with the entire Kalamazoo Interlobate subsection, KNC is completely underlain by Mississippian (Paleozoic) shale (Albert 1995, Kozlowski et al. 2005). Glacial drift thickness at KNC varies from about 50 to 100 meters (Passero et al. 1978). The land occupied by KNC was completely glaciated until ca. 12,000 years ago during the Wisconsinan glaciation, from which most of the surface material is derived (Dorr and Eschman 1970). KNC is located on the eastern edge of the Lake Michigan lobe of the Kalamazoo moraine, and on erosional terraces south of where the Kalamazoo River Valley cuts westward through the

Kalamazoo Moraine (Kozlowski et al. 2005). An esker runs northeast-southwest across the middle of the property (Figure 2).

Soils in upland areas at KNC are primarily Oshtemo sandy loams (12–35% slopes) or Kalamazoo loams (0–12% slopes). Also included are Urban soil types (e.g., gravel mines) (Austin 1979). Lowland areas support soils of the Glendora series as along the Kalamazoo River and the Houghton-Sebewa series elsewhere, supporting sedge meadow and shrub-carr.

Watersheds

KNC occurs in the central portion of the Kalamazoo River Valley, which is more than 2 km wide and 50 meters deep (Kozlowski et al. 2005). The Kalamazoo River is 250 km long and drains more than 5,000 km^2 and empties into Lake Michigan ~ 45 miles to the west-northwest (Kozlowski et al. 2005). The Kalamazoo moraine on which KNC is perched is oriented parallel to the Kalamazoo River valley. The five watersheds within KNC are Trout Run, South Stream, areas that drain directly to the Kalamazoo River, and two minor drainages in the north and northwest of the property (Figure 2).

Trout Run, the major drainage, courses through an ice block valley formed during the Wisconsinan glaciation (Vandermeulen 1982). Wetland soils are largely alkaline, with isolated acid soils (peat moss) and beds of silt detritus. The streambed is deep muck for the first 2/3 of its length, supporting sedge meadow (up to East Fen [Figure 2]); thereafter it is either sandy or gravelly (Vandermeulen 1982). Haeusler (1972) studied various chemical parameters of Trout Run within Cooper's Glen (F3), including a feeder spring along the Beech-Maple Trail. Vandermeulen (1982) analyzed water quality and other factors in Source Marsh (E2). Both found exceptional water quality.

PREVIOUS DATA

The bulk of the research done historically at KNC has been with birds, although mammals, aquatic and terrestrial insects, and reptiles and amphibians have all been the focus of research. Avian research includes over 30 years of annual bird-banding data from riparian forests, marshes, sedge meadows, and forest edge. During the years previous to and since the establishment of KNC in 1960, the flora of KNC has been surveyed (Hanes and Hanes 1947, Appendix 1). In addition to casual observations and plant collection, a three-year botanical survey of the property was conducted from 1981–1983 by plant ecologist, Louis Conde, of Cornell University. One result of this effort was to increase the collections of the on-site herbarium to at least one specimen of the majority of plant species found on the property at that time. Additional properties have been obtained since that time. Occasionally, herbarium labels included useful habitat and/or location data, however, this information is lacking for many specimens. Several ecological studies have also been conducted, mostly in Cooper's Glen (e.g., LaBatt 1961; Zager and Pippen 1977).

METHODS

During the 2003 and 2004 field seasons, surveys were conducted by the author and other KNC staff and trained volunteers for vascular plants. A species list previously compiled by KNC staff was used as a working list for compiling the annotated checklist. Only those plant species persisting outside of cultivation are included. Specimens at the KNC herbarium from various collectors (1959–1991) were verified and checked against the working list. Western Michigan University herbarium (WMU) was also searched. Collections made during this study were mostly limited to species and infra-specific taxa not yet collected and plants that were hard to identify in the field. A total of 440 collections (including duplicates) were made by the author during 2003–2004 and 2007 and have been deposited at WMU. Recording abundances in species lists is important for the purposes of comparing two sites with similar species composition (Balmer 2002) and for tracking long term change in suites of species. Abundance of individual plant species was noted on the following scale: ***rare*** *(scarce, small patch)*; ***uncommon*** *(sparse)*; **occasional** (*common but not dense, scattered)*; ***common*** *(many patches or individuals)*; ***abundant*** *(dense in most of area).*

In the annotated checklist and the accompanying text, taxonomy follows the Flora of North America (Flora of North America Editorial Committee 1993) for ferns and fern allies. Otherwise, taxonomy mostly follows *Michigan Flora* (Voss 1972; 1985; 1996).

Compartment designations

The property was delineated into compartments in ArcGIS 9.1 (ESRI, Redlands, CA) using an unpublished hierarchical land cover classification [developed by Michigan Department of Natural Resources (MDNR)] and then later refined by ground-truthing. Compartments are shown in Figure 1 and described in Table 1. A compartment does not necessarily indictate a discrete unit within which a given plant species may occur. However, placing species within deliberately defined areas of a reasonable size facilitates tracking their occurrence over time. Furthermore, the grouping of plant species on the basis of a state or regional land-cover classification (see Kost et al. 2007) adds credibility to measurements such as Floristic Quality Indices (FQIs) and the comparison of compartments based on those measures (Herman et al. 2001). In the checklist, plant species are reported within compartments only when restricted to specific locations (Appendix 2, Figure 1).

Floristic Quality Assessment

The floristic quality of each compartment of KNC was analyzed with the Floristic Quality Assessment (FQA) developed by the Natural Heritage Program of the MDNR (Herman et al. 2001). Given a list of plant species, it allows the user to calculate the mean coefficient of conservatism (C) and the floristic quality index (FQI) for the flora of the site. The coefficient of conservatism, a number between 0 and 10, "is applied to a plant based upon its fidelity to a presettlement landscape, not its rarity or legal status" (Herman et al. 2001), where a 10 indicates a plant found only in undisturbed habitats (e.g., old growth), and a 0 indicates a plant that could be found even in the most disturbed sites (e.g., recently tilled ground).

The FQI is calculated as $FQI=C * \sqrt{N}$ where N= the number of species used to calculate C (Herman et al. 2001). An area with an FQI above 35 is considered floristically important, and most likely ecologically important in the state. An area with a FQI higher than 50 is highly valued and its preservation is of utmost priority. With a complete list of plants for an area, the FQA provides a means of assessing that area based on the fidelity of those plants to presettlement conditions. Therefore, the FQA is only relevant for compartments or plant communities where a conscientious effort was made to compile a complete list of plant species.

Plot and Transect Studies

Two quantitative vegetation surveys were conducted as a part of the biological inventory. While these were primarily intended to generate baseline data to guide management of habitats at KNC, they do provide useful data in broadly characterizing the plant communities.

A set of three parallel 100 m transects was established 25 m apart in two sedge meadows (S1 and S3 on Figure 1). Percent cover of each species was recorded with a 1.0 × 0.5 m frame every ten meters along each transect. Sampling occurred between 5 September 2003 and 15 September 2003. Percent cover was aggregated into the following physiographic categories: annual and perennial forbs, ferns, perennial grasses and sedges, trees, shrubs and woody vines with the Floristic Quality Assessment software (Wilhelm and Masters 1999). Eight 0.1-hectare nested Modified-Whittaker plots were surveyed in beech-maple and floodplain forests between 24 June 2003 and 4 August 2003 (Stohlgren et al. 1995). Nested sub-plots of 1 m^2 (n=10), 10 m^2 (n=2), and 100 m^2 (n=1) were set up within each 1000 m^2 (=0.1ha) plot. Diameter at breast height (DBH) for all woody plants 10 cm DBH or greater was recorded in the 1000 m^2 plot; groundlayer and woody plants under 10 cm were recorded in small plots. Importance Values (relative density + relative frequency) were calculated for tree species greater than 10 cm DBH (McIntosh 1957).

RESULTS

A total of 702 species and infra-specific taxa of vascular plants were documented, representing 114 families (Appendix 2). Of these, 531 are considered native to Michigan, and 171 are exotics (Herman et al. 2001). Families represented by the greatest number of species are Asteraceae (84), Poaceae (69), and Cyperaceae (64). The list includes two state threatened and one state special concern species, and several that are regionally uncommon (see *Discussion*). There are 153 species and infra-specific taxa that are newly reported from KNC, 109 of which are represented by collections. Sixty-three species that were previously reported were excluded (and are not reported) based on lack of a specimen or they are assumed extirpated because habitat no longer exists where it was collected (due to disturbance or succession). Fifty-five species and infra-specific taxa have been included in the checklist based on herbarium specimens despite not having been observed during the study. The number of species per compartment varied greatly based on type of habitat, acreage, and survey effort in each compartment (Table 1). Excluding old-fields, hay fields, tilled ground and other disturbed land cover, and including only “natural” land cover types, species richness per compartment ranged from 22 (I4) to 217 (C4) (Table 1). The most widespread invasive plants are *Alliaria petiolata*, *Rosa multiflora*, *Rhamnus cathartica* (common buckthorn), and *Phalaris arundinacea* (reed canary grass).

Floristic Quality Assessment

FQIs ranged from 1.8 (M) to 62.1 (F1) (Table 1, Figure 1). Mature beech-maple forest tracts greater than 75 acres (C1–C4), sedge meadows greater than three acres (S1, S3; E1–E2), floodplain along the lower reaches ofTrout Run (F3; ~ 10 acres) (Figure 3) and southern floodplain forest along the Kalamazoo River (F1–F2; ~ 120 acres) had FQIs above 35 (Table 1, Figure 1). The Kalamazoo River floodplain had the highest FQIs (62.1, F1; 57.4, F2), followed by three beech-maple forest tracts (54.7, C1; 49.1, C4; 47.3, C3) (Table 1).

Plots and transects

Plot and transect results are not reported here in full, but some results are presented in context within the *Discussion* section. Contact author for a full report of the data. In particular, transects sampled in two sedge meadows (S1 and S3) provided insight into the vegetative structure those meadows (Table 2). Also, 0.1-hectare nested plots (Modified-Whittaker) surveyed in beech-maple and

TABLE 2. Percent cover of vascular plants by life form in two wetlands. See Figure 1 for compartment locations.

Life Form	East Fen (S1)	West Fen (S3)
Perennial sedge	43.24%	56.38%
Perennial forb	15.61%	16.79%
Perennial grass	2.76%	14.17%
Shrub	29.24%	7.72%
Fern	8.44%	4.67%
Annual forb	0.02%	0.17%
Woody vine	0.55%	0.11%
Tree	0.15%	0.00%

floodplain forests allowed for the calculation of importance values for tree species sampled (Table 3).

DISCUSSION

A floristic study provides land managers with a more complete view of a property's natural communities, thereby enabling better management of biodiversity as a whole. By illuminating the structure of habitats, it allows land managers to put a variety of land use goals into perspective, and informs other areas of research, such as watershed management, bird censuses and habitat restoration. The 1,200 acres of KNC supports a diversity of habitats and species, including some plants uncommon in southwest Michigan and statewide. Descriptions of the flora and natural communities at KNC provided below are often discussed in the context of making land management decisions.

Land management

Prescribed fire is used where appropriate. Fire frequency has historically been variable due to staffing and budget constraints, but will now occur more regularly (R. Colliton, pers. comm.). Two sedge meadows (S1 and S3) are burned oc-

TABLE 3. Importance value (out of 100) of tree species (over 10 cm DBH) from nine forested plots

Species Name	Importance Value	Species Name	Importance Value
Acer saccharum	67	*Acer rubrum*	1
Fraxinus americana	54	*Ailanthus altissima*	1
Ulmus americana	23	*Carpinus caroliniana*	1
Prunus serotina	19	*Carya cordiformis*	1
Quercus rubra	16	*Carya glabra*	1
Fraxinus nigra	4	*Fagus grandifolia*	1
Liriodendron tulipifera	4	*Malus pumila*	1
Acer saccharinum	3	*Platanus occidentalis*	1
Crataegus sp.	3	*Prunus avium*	1
Fraxinus pensylvanica	3	*Quercus macrocarpa*	1
Juglans nigra	2	*Sassafras albidum*	1
Ostrya virginiana	2	*Tilia americana*	1
Quercus velutina	2	*Ulmus thomasii*	1

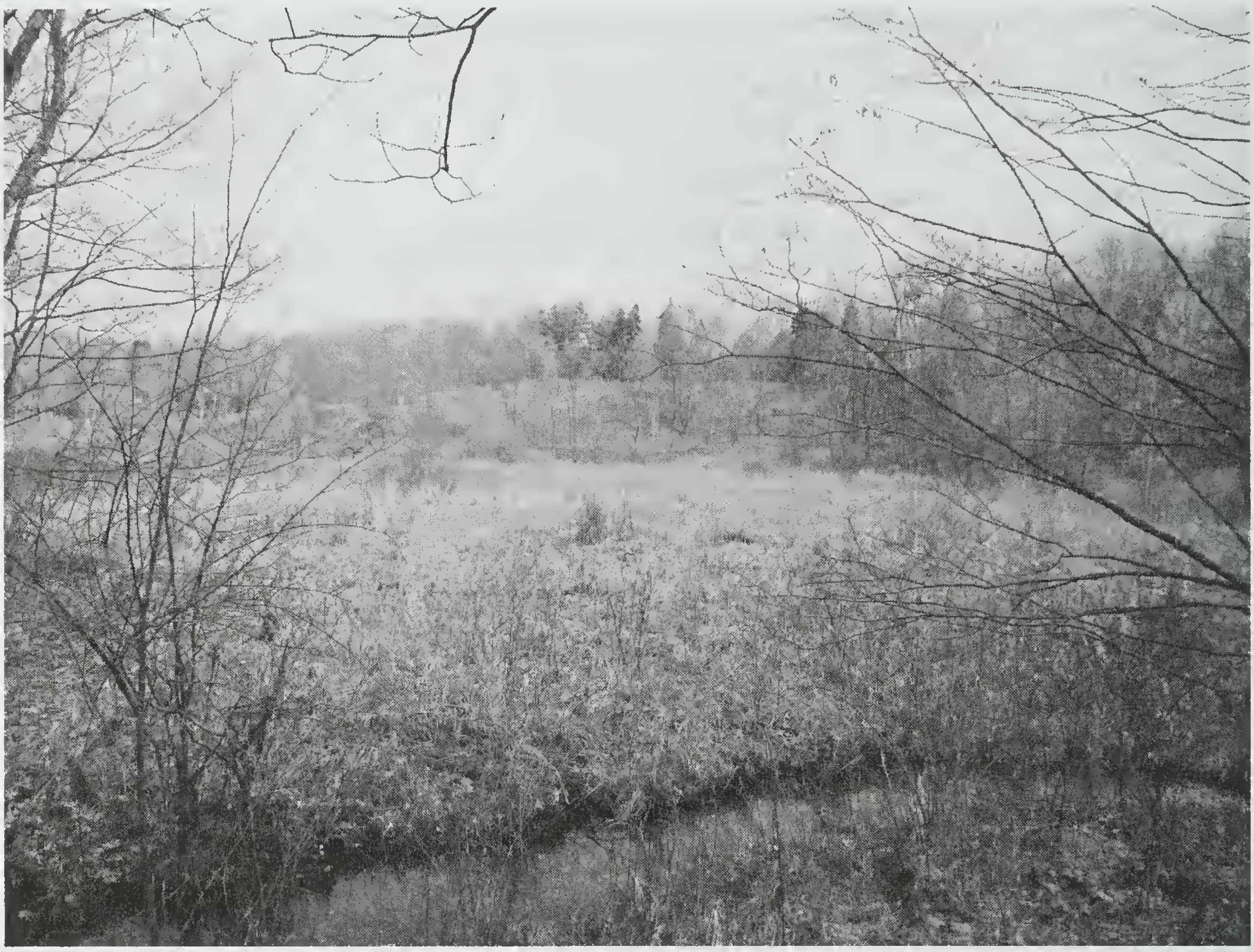

FIGURE 4. East Fen (S1), with Trout Run in foreground, and adjacent slopes in background having recently been cleared to provide nesting habitat for eastern Massasauga rattlesnakes (*Sisturus catenatus catenatus*).

casionally, and were also recently cleared of *Cornus* spp. (dogwood) and *Salix* spp. (willow). A small prairie reconstruction (Emma Pitcher Prairie) was established in the early 1970s by pioneering prairie enthusiast Robert Pleznac using locally collected seed (N1 on Figure 1), and later KNC staff used seed from this prairie to plant an adjacent tract (N2). In 2005 and 2006, 144 acres was planted to prairie by a private contractor. These prairies are also managed with fire. Upland habitat has been cleared adjacent to sedge meadows (East and West Fen), with the goal of reducing woody encroachment. Habitat for the eastern massasauga rattlesnake (*Sistrurus catenatus catenatus*) is the primary focus of these efforts (Figure 4).

Logging does not occur on the property. However, the impacts of historical forestry practices are apparent. Invasive species control occurs on a limited basis. Recent efforts have focused on controlling *Alliaria petiolata* in and near high quality patches of beech-maple forest. Other invasives controlled include *Lythrum salicaria* (purple loosestrife), *Rhamnus frangula* (glossy buckthorn), and *Elaeagnus umbellata*.

Listed species

Two vascular plant species occurring on KNC grounds are listed in Michigan as threatened (*Berula erecta* [cut-leaved water-parsnip] and *Dryopteris celsa*

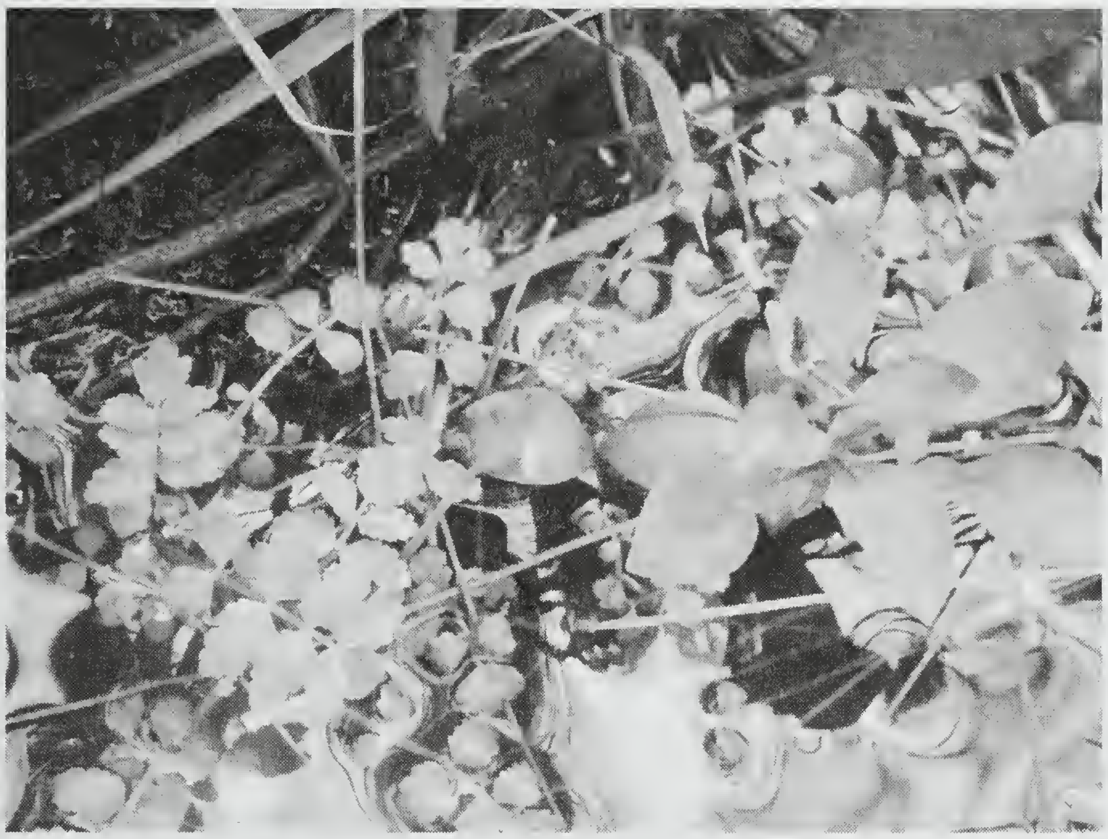

FIGURE 5. State-threatened *Berula erecta* (cut-leaved water-parsnip) on the left, *Ludwigia palustris* (water purslane) on the right. Growing along the edge of Trout Run in Source Marsh (E2).

[log fern]) and one as a species of special concern (*Aster praealtus* [willow aster]) (Michigan Natural Features Inventory 2009). *Carex frankii* (Frank's sedge) and *Liparis liliifolia* (lily-leaved twayblade) were listed as species of special concern at the time of the survey, and so are discussed here. While no longer listed species in Michigan, they are by no means common and are still of conservation concern. Species and habitat descriptions follow for the five species, including notes on habitat and protection of their occurrence at KNC.

Berula erecta (Bassett 3200) was found discontinuously along a total of approximately 400 meters of Trout Run on both sides of Westnedge Avenue (Figure 2). It is locally common in sedge meadows. This semi-aquatic member of the carrot family (Apiaceae) is frequently found in remnant prairie fens and other non-forested wetlands, but is always found in cool, calcareous waters, especially spring channels (Michigan Natural Features Inventory 2007) (Figure 5). A frequent associate is the adventive herb, *Nasturtium officinale* (water cress). In Michigan, *Berula erecta* is mostly limited to the southwest corner of the State (Voss 1985) with Kalamazoo County a stronghold of 17 occurences (Michigan Natural Features Inventory 2007). It is well-distributed across the mid- and western United States (United States Department of Agriculture, Natural Resources Conservation Service 2004). Because the KNC grounds are generally managed to ensure water quality and much of the sedge meadow in which *Berula erecta* occurs is managed with fire, these populations are sufficiently secure from water quality declines and over-shading.

Dryopteris celsa was not documented during this study, but it was reported by Harvey Ballard in the northern portion of the Kalamazoo River floodplain (F1) in 1983 (no collection has been located) (Michigan State University 2005).

Searches were made in the northern floodplain, but none resulted in a rediscovery of this rare fern. Known from rich, acidic soils in hardwood swamps and floodplain forests, it may be sensitive to excessive timber cutting and dependent upon a cyclic flooding regime (Michigan Natural Features Inventory 2007). If extant, it is not in danger of timber cutting at KNC, but the Kalamazoo River's flooding regime has the potential to be impacted by upland land use throughout the watershed and has already been affected by numerous dams along its length.

Aster praealtus (Bassett 3303) was collected by the author in the East Fen (S1) growing with other asters (*Aster firmus*, *A. puniceus*, *A. borealis*, *A. lanceolatus*). It was also collected in 1982 by Louis Conde. Hybridization is possible with any of these similar species, with which it can occasionally be confused (Voss 1996). This species status at KNC should be considered tentative until an authority on the genus *Aster* (=*Symphiotrichum*) can examine the specimens. Management of its habitat with fire will likely encourage its persistence (Michigan Natural Features Inventory 2007).

At the northern edge of its range in southern Michigan, *Carex frankii* (typically grows in southern floodplain forests (Michigan Natural Features Inventory 2007) although Hanes and Hanes (1947) note it simply from "low woods" in Climax Township, Kalamazoo County. It was collected (Bassett 3293) in the South Property at the juncture of compartments C3, E5, and F4 (Figure 1) where one of the many small seep-originated wet meadows blends the distinction between the floodplain of South Stream and the woods that surround it. Unfortunately, this collection was not recorded specifically enough to facilitate exact relocation. However, its moist habitat is likely to persist, due to the influence of groundwater seeps and the hydrological fluctuations of South Stream itself.

Liparis liliifolia was observed at three separate locations at KNC, one along the esker (O3) south of East Fen (S1), and two on wooded slopes of south DeLano woods (C5) directly above Source Marsh (E2). The site adjacent to Source Marsh, along the two-track adjacent to its southeastern edge, was made up of seven individual plants, the other two by only one plant. *Liparis liliifolia* typically occurs in mixed deciduous forest of maple and oak on damp, sandy soil (Michigan Natural Features Inventory 2007). It thrives after some disturbance or canopy removal, then diminishes and persists in low numbers in considerable shade (Case 1964, Voss 1972). It may benefit from a ground fire or selective thinning of trees in the locations where it occurs, but the effects of any management should be monitored and modified if necessary. Deer herbivory appears to be a threat (pers. obs.). The single fruiting plant observed along the esker on 14 July 2004 had altogether "disappeared" by the following day, presumably due to herbivory. Numerous subsequent attempts to relocate the plant were not successful.

Excluded Species, New Records, and Old Records Not Found

Sixty-three species previously listed as occurring at KNC have been excluded from the checklist. For example, two species of *Penstemon* that were collected along the railroad are believed extirpated, as are a number of other species of open, drier habitats (e.g., *Hieracium longipilum* [long-haired hawkweed] and *Desmodium marilandicum* [Maryland tick-trefoil]) that have since succeeded to closed-canopy conditions. Some weedy annuals were omitted if previously collected from ground that at the time was recently tilled. Some likely species were omitted due to the lack of a voucher specimen, e.g., *Eleocharis intermedia* (matted spike rush). Also excluded were plants not found out of cultivation, including planted conifers and those found only in a small prairie reconstruction in the northeast of the property (N1 and N2 on Figure 1). While these prairie plant populations are persisting without being replaced by humans, they have not spread into adjacent areas.

Fifty-five species and infra-specific taxa included in the checklist, but not found during the current study, were represented by voucher specimens in the KNC Herbarium or at WMU. Many of these are exotic weeds and were probably overlooked during this study in pursuit of more "desirable," conservative species. Species that may be considered waifs were included if multiple collections spanned more than a decade (e.g., *Anthemis arvensis*, 1959–1982) or if their persistence was otherwise deemed likely. A few conservative species were not observed during the study but are represented by a voucher specimen and are worthy of mention. The orchid *Aplectrum hyemale* (putty root) blooms in mid-spring, after which the basal leaves wither, only to return in late fall and overwinter (Case 1964). *Krigia biflora* (false dandelion), with its bright orange flowers atop a naked scape, would be hard to overlook unless restricted to a few isolated plants. Suitable habitat, however, still exists. Populations of the native bittersweet *Celastrus scandens* (American bittersweet) may be extirpated through hybridization with its exotic congener *C. orbiculata* (Oriental bittersweet) (Dryer 1994). The following sedges were collected by Hanes and Hanes (1947) and not during this study: *C. leavenworthii* and *C. careyana*. *Carex plantaginea* is abundant at KNC, with which *C. careyana* could be easily confused. *Carex leavenworthii* is considered adventive in Michigan and is represented in Michigan by only a handful of collections, all in southern counties (Voss 1972).

A total of 153 species and infra-specific taxa previously undocumented in the flora of KNC were collected or observed during the study. Some are notable additions to the known flora of KNC, primarily due to their high level of conservatism or regional or local rarity. They include *Acorus calamus* (sweet flag), *Bromus latiglumis* (ear-leaved brome), *Carex woodii* (sedge), *Sphenopholis intermedia* (slender wedge grass), *Arisaema dracontium* (green dragon), *Stachys tenuifolia* (smooth hedge nettle), *Lobelia cardinalis* (cardinal flower), *Poa alsodes* (bluegrass), *Samolus parviflorus* (water-pimpernel) in **the Kalamazoo River floodplain**; *Berula erecta, Potentilla fruticosa* (shrubby cinquefoil), *Eleocharis elliptica* (golden-seeded spike rush), *Cypripedium parviflorum* var. *makasin* (small yellow lady slipper), and the sedges *Carex interior, C. leptalea,* and *C. prairea* in **sedge meadow**; *Tiarella cordifolia* (heart-leaved foamflower), *Dryopteris intermedia* (evergreen woodfern), *Liparis liliifolia, Lonicera dioica* (red honeysuckle) and the sedge *Carex pedunculata* in **beech-maple forest**; *Ranunculus pensylvanicus* (bristly crowfoot), *Glyceria septentrionalis* (floating manna grass), *Vaccinium corymbosum* (highbush blueberry), *Alisma plantago-aquatica* (water plantain), and *Carex frankii* in **shrub swamps**; and *Platanthera lacera* (ragged fringed orchid), *Agropyron trachycaulum* (slender wheat grass), and *Asclepias verticillata* (whorled milkweed) in **disturbed habitats**. The exotics *Acer platanoides* (Norway maple), *Celastrus orbiculata,* and *Epipactus helleborine* (helleborine) are also examples of new additions. Most of these species have very limited distribution at KNC, but others are fairly well-distributed yet were overlooked in the past (e.g., *Carex prairea*). Others are likely more recent arrivals (e.g., *Asclepias verticillata, Epipactus helleborine*). Some new reports may represent differences in determination of species that were observed but misidentified in the past.

Ludwigia palustris (water purslane) (Bassett 4361) (Figure 5), *Samolus parviflorus* (Bassett 4281), and *Tiarella cordifolia* are new reports for Kalamazoo County (Reznicek et al. 2009). Of particular note is *T. cordifolia,* which was observed near Pond 12 along the Fern Valley Trail (Figure 1) on May 21, 2008 by Todd Barkman (Figure 6). Found mostly in the northern and southeastern Lower Peninsula to Jackson County, the only other southwest Michigan collection is from Berrien County (Reznicek et al. 2009). This species is occasionally planted, however, there are no records of it being planted at KNC.

NATURAL COMMUNITIES

Much of KNC supports high quality palustrine and terrestrial communities, as recognized by MNFI's natural community classification scheme (Kost et al. 2007). In the discussion that follows, each community is identified with a letter and number code indicating its rarity within the state (S#) and globally (G#). These designations are based on known occurrences, following Natural Heritage methodology developed by The Nature Conservancy (Kost et al. 2007). An S1 rank means "critically imperiled in the state because of extreme rarity (5 or fewer occurrences or very few remaining individuals or acres) or because of some factor(s) making it especially vulnerable to extirpation in the state." A community is given an S2 ranking if it is "imperiled in state because of rarity (6 to 20 occurrences or few remaining individuals or acres) or because of some factor(s) making it very vulnerable to extirpation from the state." Communities with a state ranking of S3 are defined as "rare or uncommon in state (on the order of 21 to 100 occurrences)." S4 communities are secure and S5 are extremely secure. SU indicates an unknown ranking. The global ranks are comparable in definition, but on a global scale.

PALUSTRINE

Estimates of wetland acreage in Michigan have decreased from 11 million in 1850 to 3 million today (Langworthy, Strader, LeBlanc and Associates, Inc. 2001). Wetland preservation is critical for wildlife habitat and water quality, but the preservation of uplands in a watershed is equally important. This provides necessary protection for wetlands, because properly managed uplands filter much of the contamination originating in a watershed, slow stormwater runoff, and act as recharge areas for groundwater-fed wetlands. Two watersheds, Trout

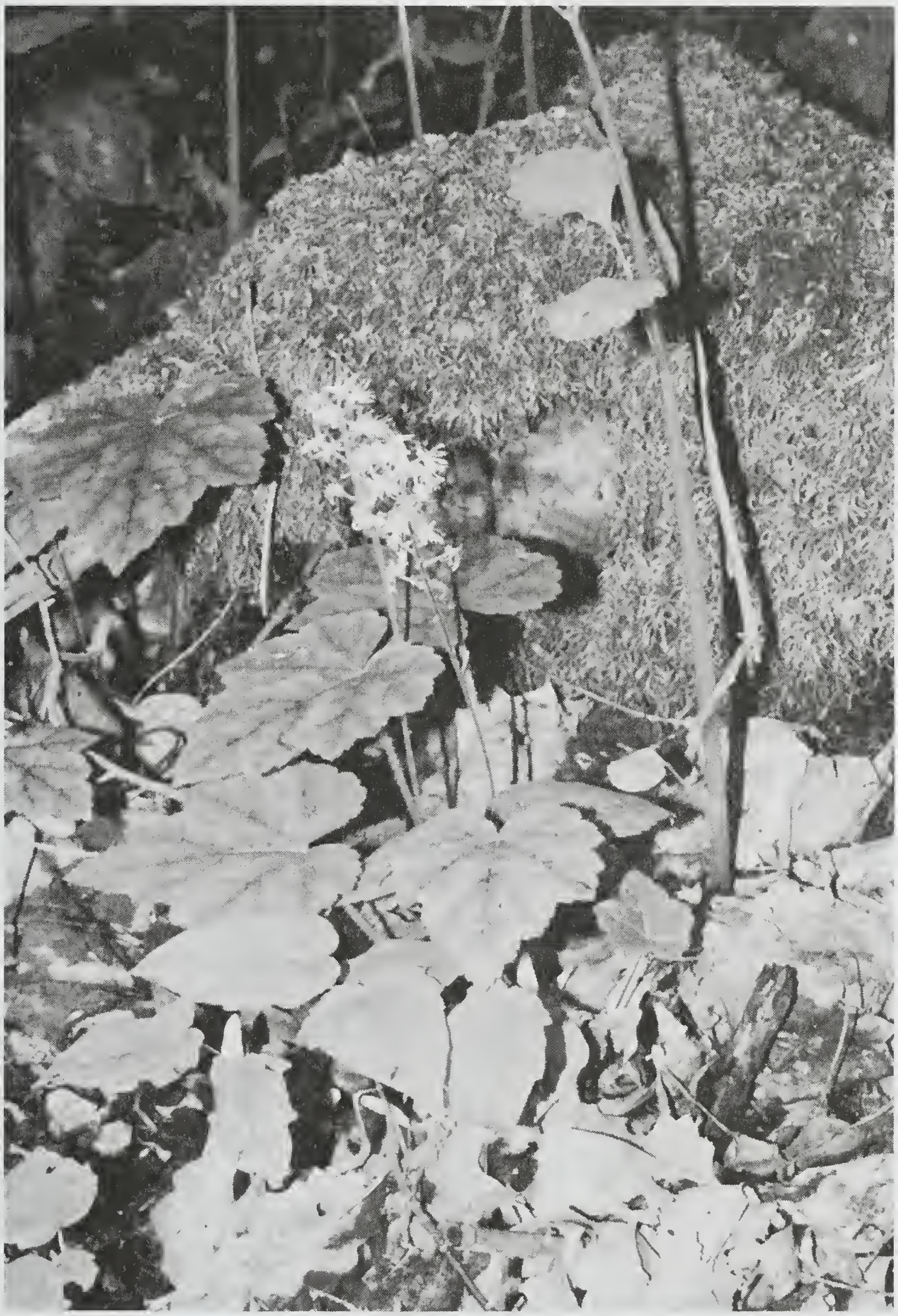

FIGURE 6. *Tiarella cordifolia* (foamflower), a species common in northern cedar swamps, but uncommon in the south. In Cooper's Glen (C1). Photo by Anne Royer.

Run and South Stream, are mostly within the boundaries of KNC (Figure 2). This provides excellent opportunities for managing wetland buffers and controlling stormwater within these watersheds.

Southern wet meadow (rank=S3G4)

Southern wet meadow, or sedge meadow, occupies about 47 acres (19.5 hectares) at KNC. This groundwater-influenced community is found bordering

Trout Run, on the springy slopes above South Stream, in backswamps and old oxbows along the Kalamazoo River, and in a few isolated areas of groundwater discharge. Sedge meadow is indicated in Figure 1 as compartments S1–3 and E1–5.

As is typical of sedge meadows, *Carex stricta* (tussock sedge) is the usual dominant at KNC, with *Calamagrostis canadensis* (bluejoint grass) a significant component (Kost 2001; Kost and DeSteven 2000) (Figure 7). Some portions of sedge meadow are dominated by *Carex lacustris* (sedge). *Carex stricta* can occupy a density of 1–4 hummocks/m^2 and as much as 40% cover in a meadow (Kost 2001). The two sedge meadows studied at KNC showed a cover of 43.24% (S1) and 56.38% (S3) for all Cyperaceae (Table 2) (including bulrushes [*Scirpus* spp., *Schoenoplectus* spp.] and other *Carex* spp., *inter alia*). Shrub cover was 29.24% (S1) and 7.72% (S3) (Table 2). The shade-intolerant *Carex stricta* is sensitive to enroachment by shrub species with which it is associated, primarily *Cornus* spp., *Salix* spp. and *Rhamnus frangula*. *Rhamnus frangula* is not a major problem in most of KNC's wetlands, and *Cornus* spp. and *Salix* spp. are effectively managed with fire and cutting where desirable. *Phalaris arundinacea* is invasive in some sedge meadows, such as in the Kalamazoo River floodplain and especially in a four-acre meadow in the upper South Stream immediately east of Westnedge Avenue (E4) where it grows as a monoculture except in local seepage areas.

A number of rare or uncommon plant species require open conditions in the

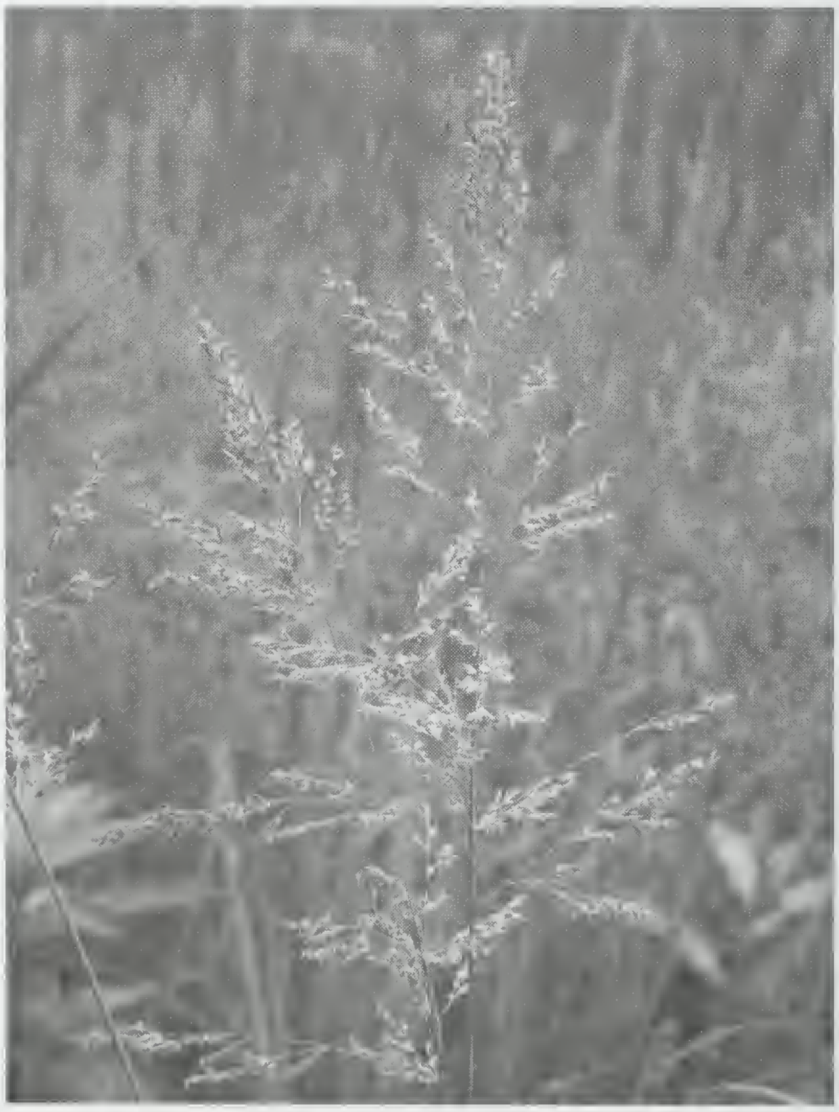

FIGURE 7. *Calamagrostis canadensis* (blue-joint grass), a dominant in some portions of sedge meadow.

sedge meadows, including *Berula erecta*, *Rudbeckia fulgida* (brown-eyed Susan), *Aster praealtus*, *Cypripedium parviflorum* var. *makasin,* and *C. reginae* (showy lady's slipper). Populations of *Rudbeckia fulgida* occur in seepage areas at either end of East Fen. It generally grows in calcareous fens and sedge meadows and depends on the groundwater infusion and unshaded conditions of the sedge meadow (Legge et al. 1995). Another attractive wetland wildflower, *Cypripedium reginae*, occurs in Source Marsh near its narrowest point (E1, near the boundary with E2). It requires open conditions and prefers calcareous soils (Case 1964). A total of three stems were observed both in 2003 and 2004; flowering occurred only in 2003. Fruiting plants were observed in 2007. Less than ten sterile stems of *Cypripedium parviflorum* var. *makasin* were observed in the Kalamazoo River floodplain (F1) in fall of 2008, in areas dominated by either *Carex lacustris* or *Carpinus caroliniana* (blue-beech).

Typical species at KNC sedge meadows include *Lysimachia thyrsiflora* (tufted loosestrife), *Campanula aparinoides* (marsh bellflower), *Eupatorium maculatum* (Joe pye weed), *Eupatorium perfoliatum* (boneset), *Gentiana andrewsii* (bottle gentian), *Solidago riddellii* (Riddell's goldenrod), *Rudbeckia hirta* (black-eyed Susan), *Aster lanceolatus* (eastern lined aster), *Angelica atropurpurea* (angelica), and *Lilium michiganense* (Michigan lily) (Figure 8).

Seeps are common within the sedge meadows at KNC and along the Kalamazoo River floodplain. When seeps occur in areas of strongly calcareous substrate, marl flats may occur (Figure 9). These are either small isolated pockets or large, wide areas; dominant plant species are all those tolerant of high alkalinity. Some examples are *Lobelia kalmii* (Kalm's lobelia), *Lysimachia quadriflora* (whorled loosestrife), *Agalinis purpurea* (purple gerardia) and *Rhynchospora capillacea* (beak-rush). The best example of a seep is found on the far west end of Source Marsh (E2).

Spring flooding is common and historically, beaver may have maintained the open character of sedge meadows by flooding; fire has also been historically important (Kost 2001). Because flooding is logistically difficult or impractical, fire is absolutely necessary to maintain openness and reduce woody cover. Many sedge meadows have been used for marsh hay, or tiled, ditched, or drained and converted to pasture, row crops, or mined for peat. At the constriction of Source Marsh, near the border between E1 and E2 (Figure 1), a livestock fence bisects the wetland, suggesting historical pasturing in this apparently undrained wetland complex.

Most sedge meadow at KNC is managed with manual shrub removal and prescribed fire to maintain an open condition. A diversity of plant and animal species at KNC, including some rare species, depend upon this condition. The eastern massassauga rattlesnake is a candidate for listing under the Federal Endangered Species Act and has been seen using the property for at least the last 45 years, although reports have been declining in recent years (R. Adams, pers. comm.). Other rare animals in the sedge meadow habitats on the property are the eastern box turtle (*Terrapene carolina carolina*) (Figure 9), spotted turtle (*Clemmys guttata*) and Blanding's turtle (*Emydoidea blandingii*). Sedge meadows typically support few bird species (R. Brewer, pers. comm.). The rare species observed near East Fen, hooded warbler (*Wilsonia citrina*) and cerulean warbler

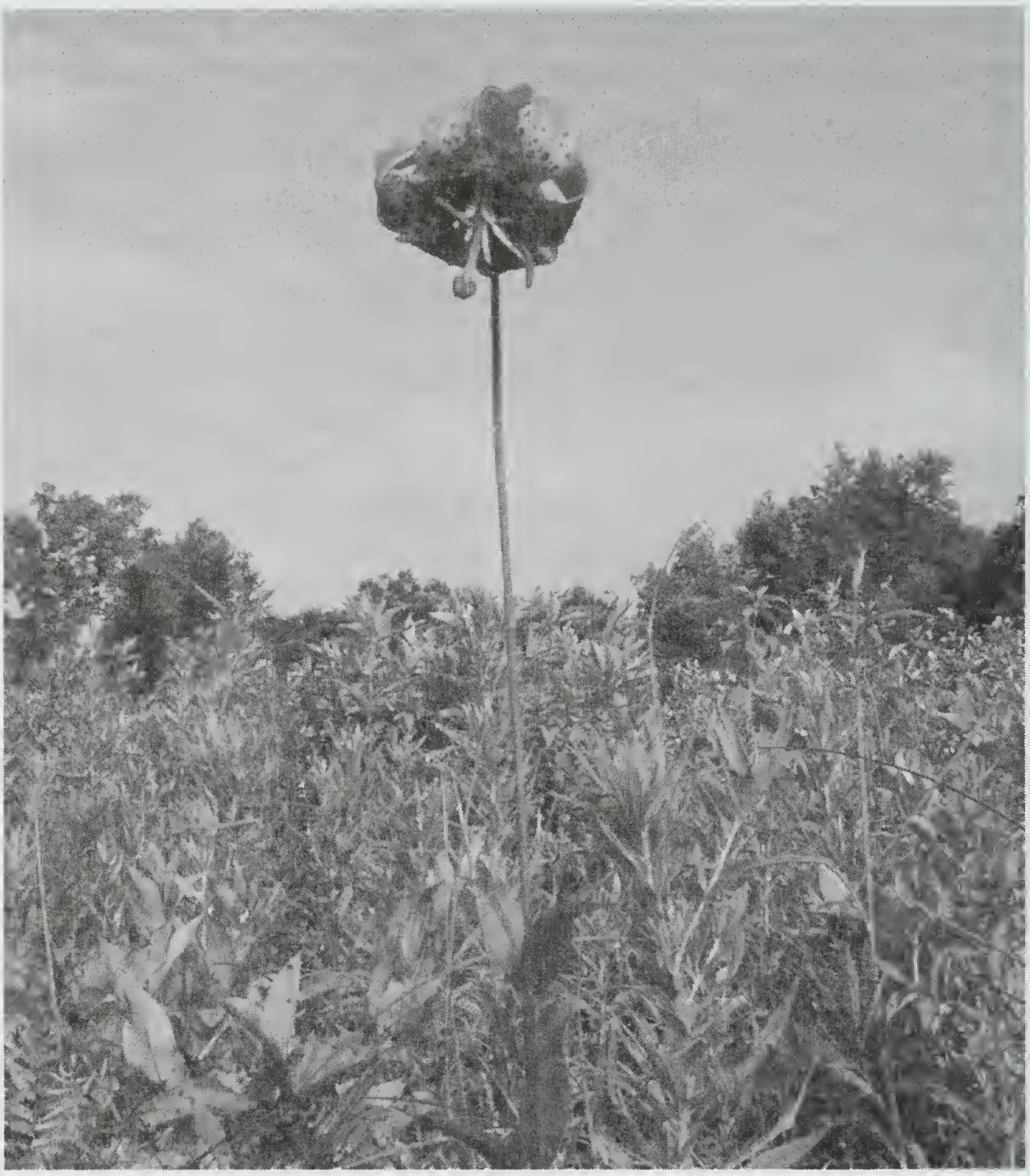

FIGURE 8. *Lilium michiganense* (Michigan lily), in East Fen (S1).

(*Dendroica cerulea*), are forest interior and edge species and were observed on its shrubby border.

Southern wet meadow is often interspersed with southern shrub-carr (see below), and shares borders with swamp forest and emergent marsh in large wetland complexes, usually in depressions in glacial outwash along the margin of a stream as in the meadow along Trout Run west of Westnedge Ave. (E1, E2).

Southern shrub-carr (rank=S5GU)

In the absence of fire or flooding, sedge meadow will typically succeed into shrub-carr, which occurs as patches within KNC sedge meadows. Shrub-carr is often a successional community between open wetland (e.g., sedge meadow) and swamp forest; it also frequently occurs as a component in a larger wetland complex (Kost et al. 2007). This is certainly the case in wetlands at KNC. Dominant shrubs include *Cornus* spp. and *Salix* spp.; *Ilex verticillata* (winterberry) and *Sambucus canadensis* (elderberry) are often important components. Shrub-carr supports *Scutellaria lateriflora* (mad-dog skullcap), *Apios americana*

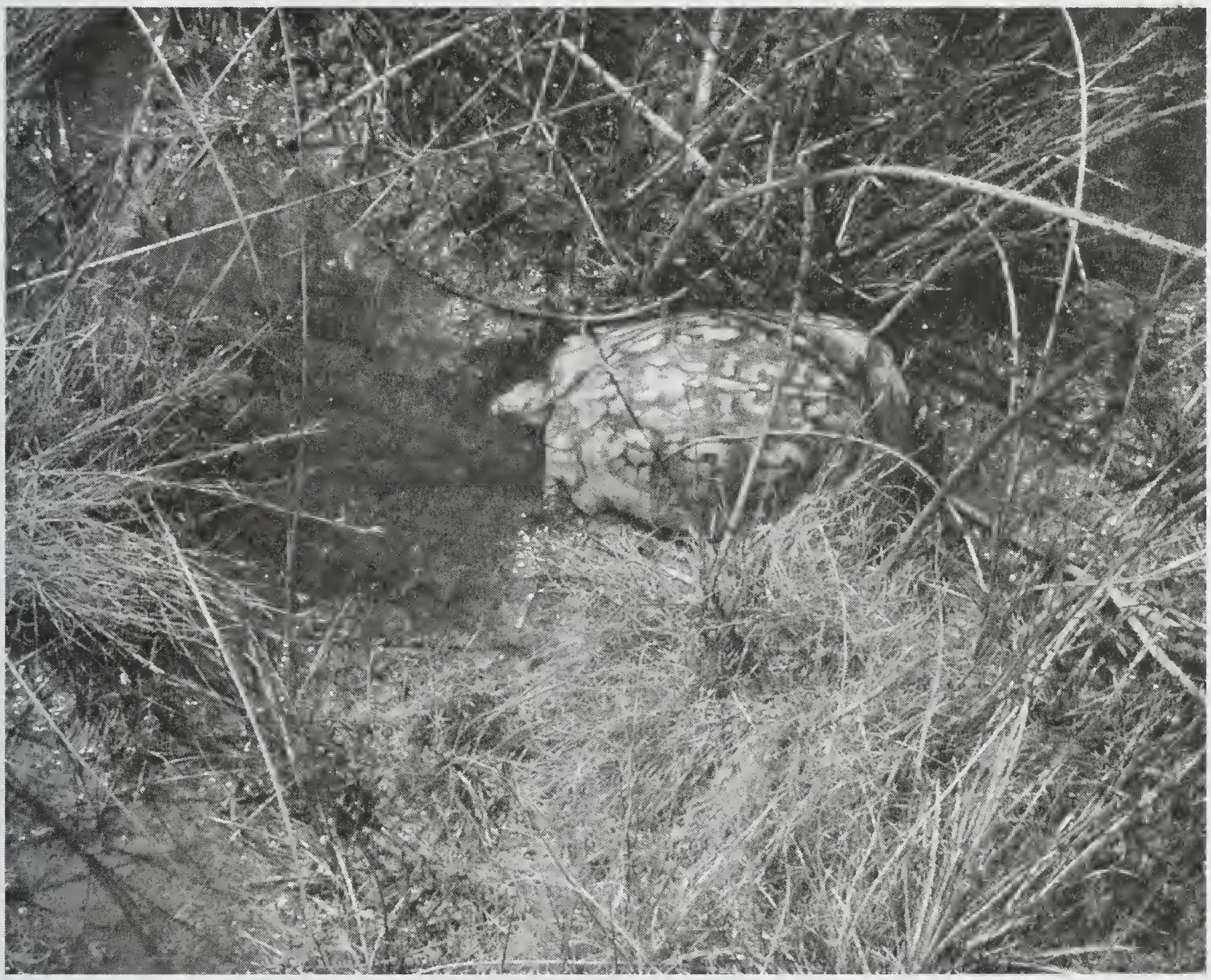

FIGURE 9. Eastern box turtle (*Terrapene carolina carolina*) cooling itself in the marl flat near the source of the Source Marsh (E2).

(groundnut), *Lycopus uniflorus* (northern bugleweed), *Cuscuta gronovii* (common dodder), *Galium* spp. (bedstraw) and a number of species typical of sedge meadow.

Inundated shrub swamp (rank=S3G4)

Inundated shrub swamp is common in kettle/kame (ice-contact) ice-disintegration topography such as is found at KNC, and is usually situated in small kettleholes (Kost et al. 2007). These commonly hold 1–2 feet of water and are indicated by the prevalence of *Cephalanthus occidentalis* (buttonbush). They are often associated with emergent marsh and/or bog. At KNC, shrub swamps occur as isolated forest depressions (e.g., I3–4) (Figure 10); in one instance a “lobe” or “arm” of Source Marsh (E2), a kettlehole feature, is isolated enough from the rest of the marsh to form a shrub swamp (“Lobe” on Figure 2). This is very boggy, dominated by *Ilex verticillata* rather than *Cephalanthus occidentalis*, and the only known location for sphagnum moss (*Sphagnum russowii* [Ehrle 2005]) and *Alisma plantago-aquatica* at KNC, and one of two for *Chrysosplenium americanum* (golden saxifrage) (Figure 11) and *Vaccinium corymbosum*. As with vernal pools, shrub swamps are extremely important breeding grounds for amphibians and reptiles.

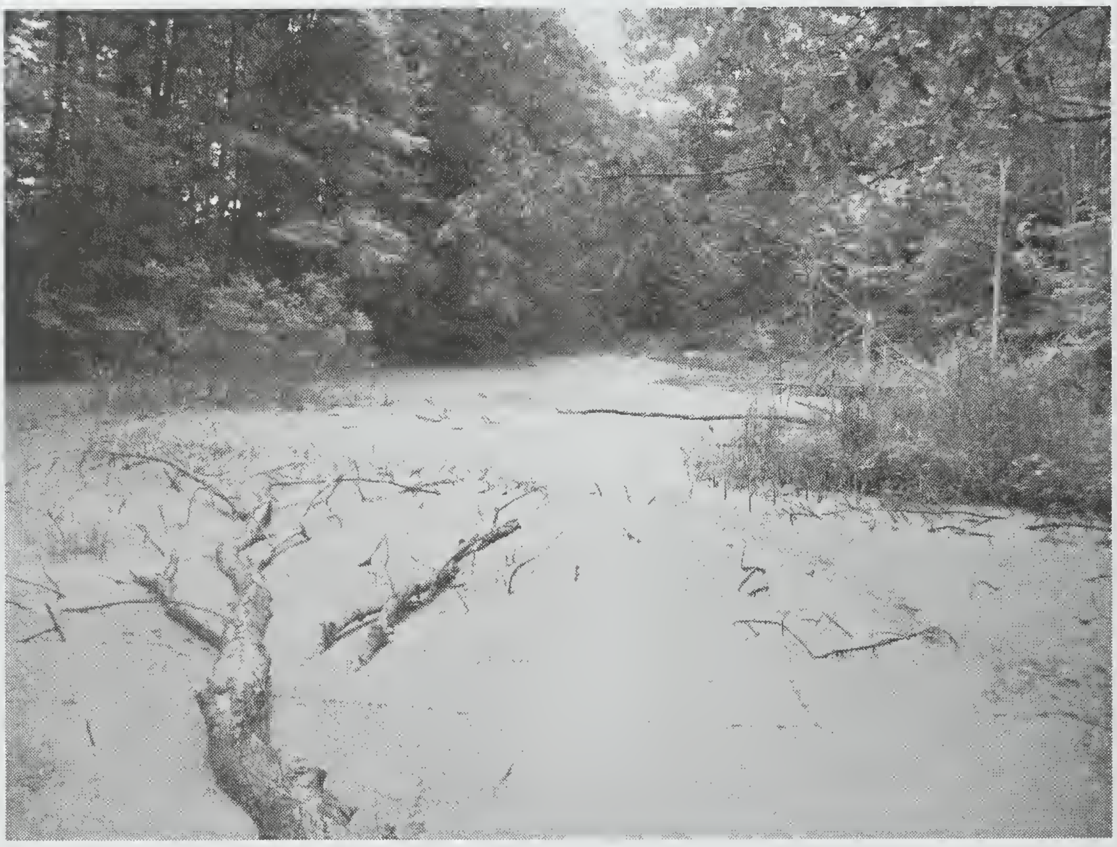

FIGURE 10. Isolated depression (I4) in beech-maple forest with *Cephalanthus occidentalis* (buttonbush) thicket developing on the left.

Emergent marsh (rank=S4GU)

Emergent marsh occurs on the border of sedge meadow and is indicated by the presence or dominance of *Typha latifolia* (broad-leaved cattail), *Sagittaria latifolia* (common arrowhead), *Sparganium* spp. (bur-reeds) and other species which occur as emergent or floating-leaved plants (Kost et al. 2007). Small areas of emergent marsh are found in the backwaters of the Kalamazoo River floodplain and Trout Run, mostly adjacent to sedge meadow and groundwater seepage streams. They often occur as "cattail marshes," because of the dominant species. *Typha* spp. (*T. latifolia*, *T. angustifolia* and their vigorous hybrid *T.* × *glauca*) which appear to be expanding their range eastward as well as becoming more invasive and causing habitat degradation (Shih and Finkelstein 2008). They respond positively to siltation, salinization, and other anthropogenic disturbances. Cattail marshes at KNC are generally small patches within sedge meadows and co-dominate with sedges (e.g., *Carex hystericina, C. lurida, C. comosa, C. lacustris*) and a few forbs such as *Lysimachia thyrsiflora, Pilea pumila* (clearweed), and *Lycopus americanus* (common water horehound). This limited dominance at KNC and their tendency to gradually grade into sedge-dominated areas suggests watershed and community stability.

Southern floodplain forest (rank=S3G3)

Southern floodplain forests occupy approximately 124 acres (50 ha) of mostly high quality habitat at KNC. Canopy dominants in KNC's southern floodplain forest include *Acer saccharinum* (silver maple), *Fraxinus pennsylvanica* (red ash), and *F. americana* (white ash) while *F. nigra* (black ash), *Platanus occidentalis* (sycamore), *Quercus bicolor* (swamp white oak), and *Q. macrocarpa* (bur oak) are locally common in wetter or drier microhabitats such

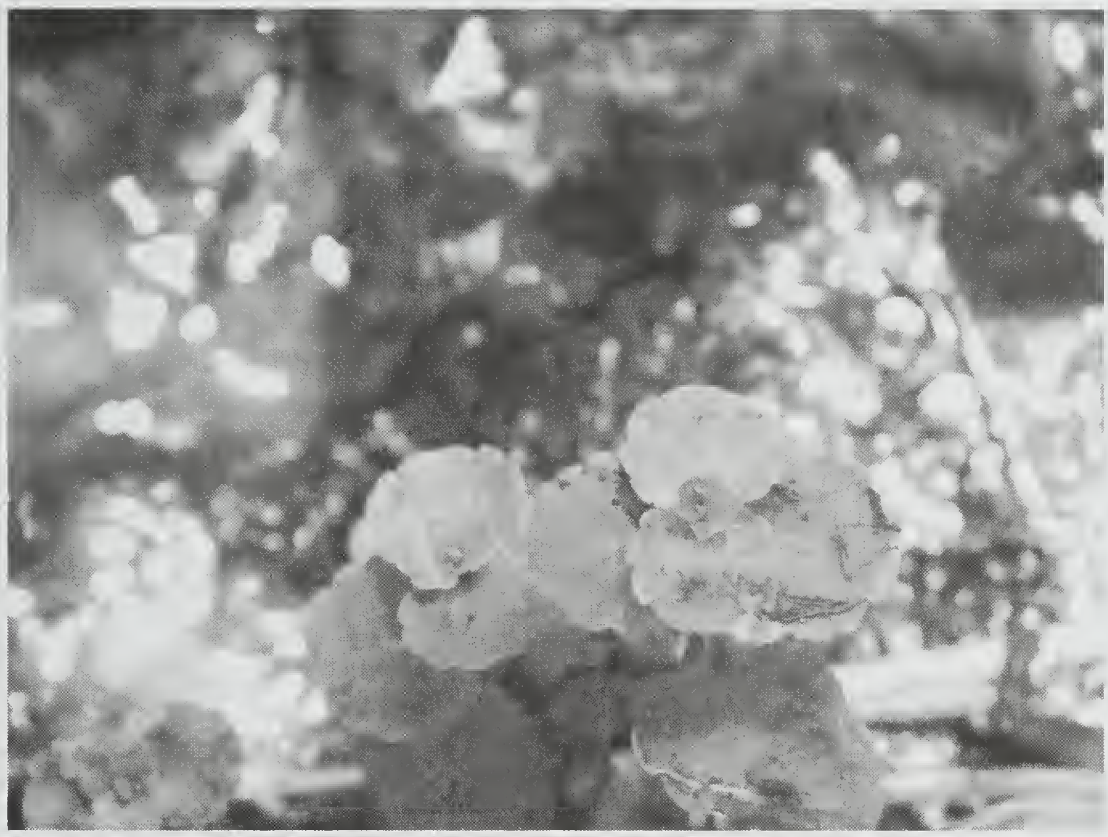

FIGURE 11. *Chrysosplenium americanum* (golden saxifrage) along shaded seepage stream in shrub swamp (I2).

as "bottoms" and levees. *Dentaria diphylla* (two-leaved toothwort), *D. laciniata* (cut-leaved toothwort), *Brachyelytrum erectum* (long-awned wood grass), *Bromus pubescens* (Canada brome), *Poa alsodes, Trillium grandiflorum* (common trillium), *Hydrophyllum appendiculatum* (great waterleaf), and *Viola pubescens* (yellow violet) are locally common in different microhabitats of this heterogenous community.

Disturbance is the norm in these forests, marked by periodic floods, erosion, silt deposition, and light gaps created by fallen trees (Figure 12) (Tepley et al. 2004). Frequent deposition makes floodplain soils very fertile, and they were used extensively by Native Americans for growing maize (Curtis 1959). However, frequent disturbance and high nutrient input makes floodplain forests susceptible to invasions by exotic species. Dispersal through the riparian corridor and a pronounced negative "edge effect" are also factors (Murcia 1995). The frequency of *Lysimachia nummularia* (creeping Jenny) and *Rhamnus cathartica* are two striking examples of this effect. The invasive insect emerald ash borer, accidentally transported into the United States from eastern Asia in shipping cargo as recently as 2002 (Michigan Department of Agriculture [MDA] 2005) is devasting ash trees across southern Michigan, but has not been observed at KNC to date. *Fraxinus americana* and *F. pennsylvanica* are common dominants and *F. nigra* is locally dominant along the Kalamazoo River floodplain. A shift in canopy dominance away from *Fraxinus* spp. may have far-reaching effects on the ecology of this community.

Many southern tree species occur in southern Michigan in floodplain forests, partly because lower temperatures typical of lower ground cause buds to break later, thus avoiding kills from late spring frost, and also because river systems provide corridors for the movement of propagules (Tepley et al 2004). Many

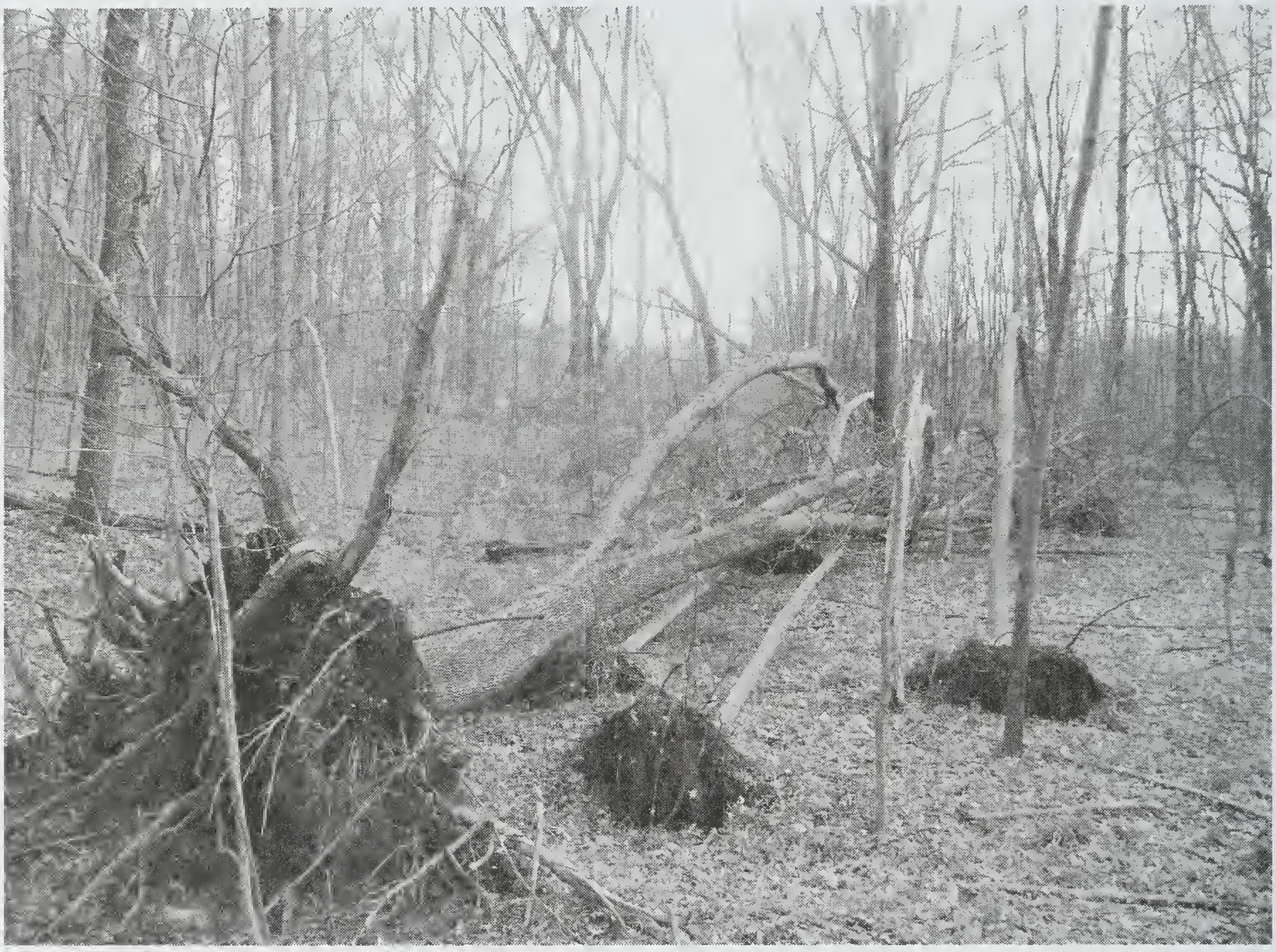

FIGURE 12. Tree tip-up in floodplain forest (F1).

southern species are found at KNC, including *Celtis occidentalis* (hackberry), *Cercis canadensis* (redbud), *Gleditsia triacanthos* (honey locust), *Platanus occidentalis*, and others. Many salamanders, frogs, and toads utilize the vernal pools that are common in this and other communities. Southern floodplain forest also provides habitat for a few rare riparian bird species, such as the special concern prothonotary warbler (*Protonotaria citrea*) and Louisiana waterthrush (*Seiurus motacilla*) observed during the inventory. Other rare species observed in KNC's floodplain forest are the vascular plants *Dryopteris celsa* and *Carex frankii*; the mollusks elktoe (*Alasmidonta marginata*) and widespread column (*Pupilla muscorum*); the birds Cooper's hawk, hooded warbler, and bald eagle (*Haliaeetus leucocephalus*); and the spotted and eastern box turtle.

Juglans cinerea (butternut) is of conservation concern throughout its range. Occurring throughout much of the eastern United States, it has seen as much as an 80% decrease in some areas, largely due to the fungus *Sirococcus clavigignenti-juglandacearum* (butternut canker) (United States Department of Agriculture, Forest Service 2005). Butternut husks were observed at numerous locations throughout the grounds of KNC, mostly along streams. No trees or fresh fruits were discovered. The native range of *Gleditsia triacanthos* is predominantly south of Michigan, and within Michigan the species occurs only in the southern two or three tiers of counties (Burns and Honkala 1999). At KNC, its occurrence is local. Small populations of *Gleditsia triacanthos* occur at two locations along the southern Kalamazoo River floodplain (F2).

The floodplain of the Kalamazoo River supports several locally rare herbs, including *Physostegia virginiana* (false dragonhead), *Samolus parviflorus* and *Arisaema dracontium. Physostegia virginiana* occurs in two partly shaded locations in damp soil but with little or no standing water, separated by more than one mile (F1, F2). *Arisaema dracontium* was not observed in bloom, but its distinctive leaf shape was noticed in two locations within one-half mile (~ 800 meters) of each other in the dense shade of the northern floodplain (F1) under *Acer saccharinum, Fraxinus pensylvanica,* and *Ulmus americana. Samolus parviflorus* was collected in an exposed mud flat in a seep along the Kalamazoo River (F2), enduring little interspecific competition. Other species of interest supported by this community include *Carex lupulina, C. woodii, Teucrium canadense* (wood sage)*, Stachys palustris* (woundwort)*, S. tenuifolia* and *Sisyrinchium angustifolium* (blue-eyed grass).

TERRESTRIAL

The beech-maple forests at KNC represent some of the highest-quality remnants in southwest Michigan (Figure 13, see cover image). In fact, it is Cooper's Glen, with its impressive spring wildflower displays and neotropical bird migrations, that originally inspired the purchase and ultimate preservation of the lands now occupied by KNC. This forest still stands today as the centerpiece of KNC's interpretive experience, and is as diverse as it was when Clarence and Florence Hanes botanized here in the 1930s (Hanes and Hanes 1947, Appendix 1) and H. Lewis Batts, Jr. began bringing his students in the 1950s. Southwest Michigan's historical oak savannas and prairies, with the exclusion of fire, have grown into a considerable acreage of oak forest (Comer et al. 1995). What is largely missing from the landscape are the beech-maple forests and forest cover along the Kalamazoo and other rivers. Perhaps more than any other forest type in Michigan, they are fragmented and degraded and eliminated outright by the pressures of urbanization and agriculture. The forests of KNC play an important role in preserving the diversity inherent in these forests.

Mesic southern (Beech-maple) forest (rank=S3G2/G3)

Beech-maple forest occupies about 459 non-contiguous acres (186 ha) at KNC. Two tracts are of higher quality, Pioneer Woods (C4, 49.1 acres) and Cooper's Glen (C1, 54.7 acres). Three other tracts (C2, C3, C5) are in various stages of succession. Areas along the Kalamazoo River on the terraces above the floodplain also contain high quality variants of this community that blend into the floristically similar southern floodplain forest community. Beech-maple forests at KNC occur along the edge of the Kalamazoo moraine on flat topography and up to 35% slopes on silt loam to sandy loam soils, which is typical of this community (Austin 1979; Cohen 2004). Statewide, beech-maple forests are largely confined to disturbed 40-acre farm woodlots (compared to a historical mean patch size of 9,000 acres) (Cohen 2004). At KNC, patches vary in size from 28 to 128 acres.

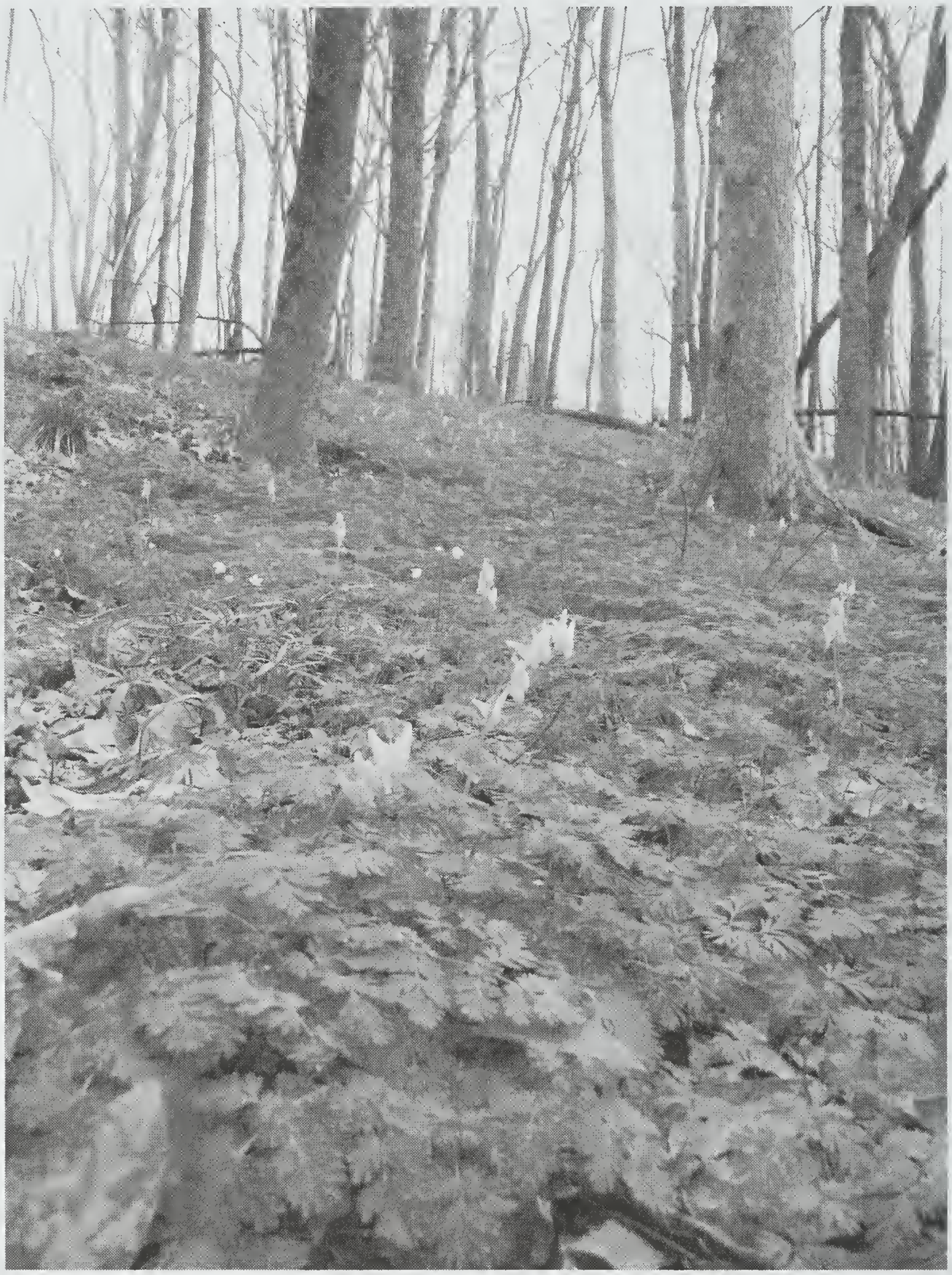

FIGURE 13. Cooper's Glen (C1) with dense carpet of *Dicentra cucullaria* (Dutchman's-breeches) and open understory.

Mature conditions in beech-maple forest are indicated by multi-generational stands with large canopy dominants (*Fagus grandifolia*, *Acer saccharum*), significant amounts of coarse woody debris, and pit-and-mound micro-topography (Cohen 2004). All of these conditions are present in Cooper's Glen and Pioneer Woods, although generally to a lesser extent than would be expected in an old-growth stand.

Fagus grandifolia (American beech) and *Acer saccharum* (sugar maple) are the typical community dominants. In Modified-Whittaker plots at KNC, *Acer saccharum* dominated with an Importance Value (IV) of 67 (out of 100) (Table 3). Other dominant trees include *Fraxinus americana* (54), *Quercus rubra* (red oak) (16), and in more disturbed tracts, *Prunus serotina* (wild black cherry) (19) and *Ulmus americana* (American elm) (22). Other typical canopy trees such as

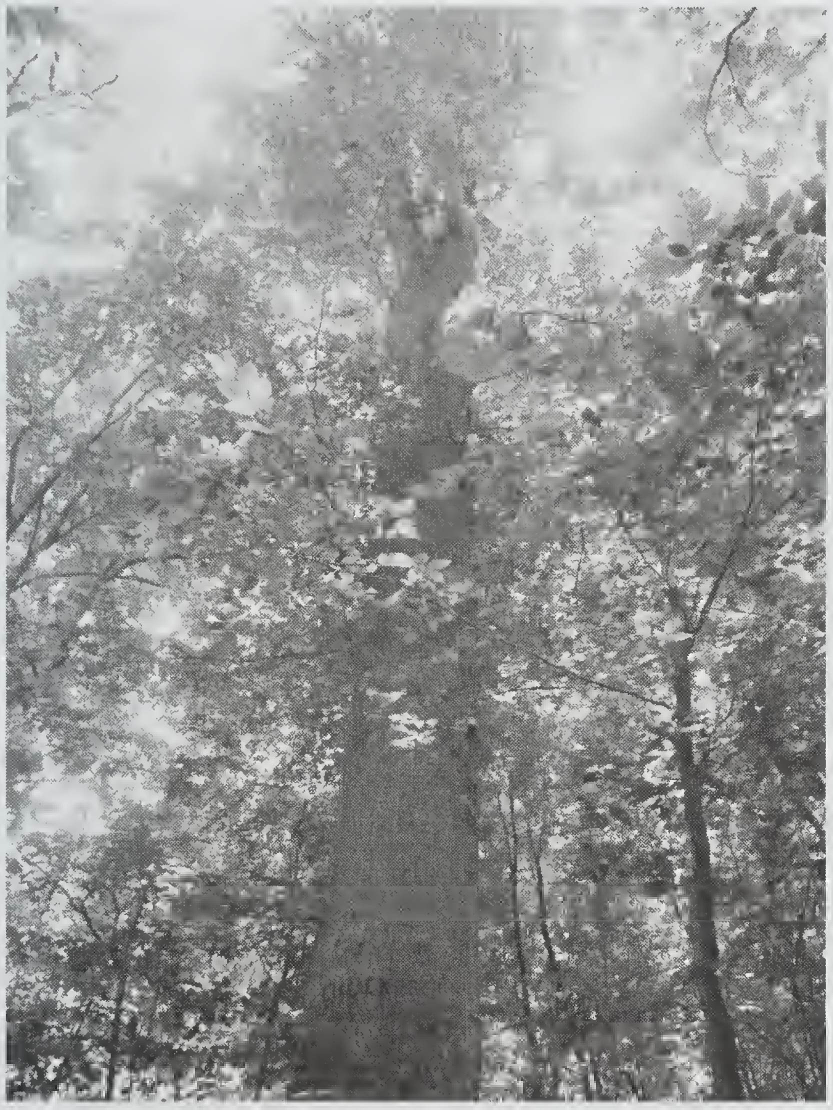

FIGURE 14. One of several large *Fagus grandifolia* (American beech) in Pioneer Woods (C4).

Liriodendron tulipifera (tulip poplar), *Tilia americana* (basswood), and *Carya cordiformis* (bitternut hickory) occur only occasionally. Surprisingly, *Fagus grandifolia* was not well-represented in modified-Whittaker plots, occurring only once. This may be an artifact of the random placement of plots, because both Cooper's Glen and Pioneer Woods support many large, old *Fagus grandifolia* trees and would have been expected to be more frequent (Figure 14).

Spring ephemerals are abundant in KNC's beech-maple forests. *Erythronium americanum* (yellow trout lily), *Claytonia virginica* (spring beauty), *Viola pubescens*, *Sanguinaria canadensis* (bloodroot), *Floerkea proserpinacoides* (false mermaid), *Phlox divaricata* (woodland phlox) and numerous other common forest wildflowers dominate the groundlayer in spring. *Erigenia bulbosa* (harbinger-of-spring) is more limited in distribution but occurs in both Pioneer Woods and Cooper's Glen. One of the most impressive features is a hillside carpeted with *Collinsia verna* (blue-eyed Mary), along the Beech-Maple Trail in Cooper's Glen (C1) (Figure 15). *Collinsia verna* appears to be limited to only large, high quality remnants of this forest community in southwest Michigan (e.g., Cooper's Glen, Dowagiac Woods, Warren Woods) (pers. obs.). As a winter annual, its persistence is dependent upon maintaining a robust seedbank (Kalisz and McPeek 1993). An advancing front of *Alliara petiolata* is cause for concern.

Canopy gaps from windfall or diseased, stressed, and old trees comprise the natural disturbance regime in beech-maple forest, a process known as gap-phase dynamics (Watt 1947). Normally, many trees fall concurrently during isolated extreme weather events (Brewer and Merritt 1978). The frequency and size of

FIGURE 15. *Collinsia verna* (blue-eyed Mary), in Cooper's Glen (C1), where it forms a carpet every spring.

these gaps dictates canopy composition, through the differential release of tree saplings from light, water, and nutrient competition (Poulson and Platt 1996). Donnelly (1986), studying gaps in old growth beech-maple forest in nearby Warren Woods (Berrien County, Michigan), found that these gaps close in about 34 years, although others have estimated as little as 11 years (Canham 1990). The majority of stems released from shade-suppression by these gaps are *Acer saccharum* and *Fagus grandifolia* not typical successional species like *Prunus serotina*, *Fraxinus americana*, and *Ulmus americana*, although these species are present in gaps (Brewer and Merritt 1978, Donnelly 1986). Successional species gain dominance in larger gaps or in younger forests, as in some tracts at KNC (Runkle 1984). Many researchers have found that almost all small gaps are replaced by the canopy dominants *Fagus grandifolia* and *Acer saccharum*, the seedlings of one species doing best under a canopy of the other (Brewer and Merritt 1978, Woods 1979, Runkle 1984). *Fagus grandifolia* appears to exhibit higher shade tolerance and greater survivorship and is favored by old growth, less disturbed and more shaded conditions, including long intervals between gap events, while *Acer saccharum* is favored by more frequent disturbances (Donnelly 1986, Canham 1990, Poulson and Platt 1996, and Runkle 1984). Furthermore, heavy-textured moraines such as at KNC may favor *Acer saccharum*, while *Fagus grandifolia* is more common in the acidic, poorly-drained lakeplain (Cohen 2004). Nonetheless, the apparent reduced regeneration of *Fagus grandifolia* in KNC's otherwise mature forests (especially Cooper's Glen) is puzzling (R. Adams, pers. obs.). Donnelly (1986) also points out that *Acer saccharum* may dominate in smaller and more disturbed forest patches typified by more frequent treefall caused by stand isolation and prolonged canopy opening as a result of historical thinning. Light gaps due to the presence of streams, wetlands, and trails within, as well as the small size of the two most mature beech-maple stands (C1, C4) may account for some the dominance of *Acer saccharum* (pers. obs.). The conditions at the outset of post-logging forest succession at Cooper's Glen may have favored *Acer saccharum*. Diversity in beech-maple forests is driven by gap-phase dynamics (or, some would suggest, infrequent catastrophic fires) which can not be easily simulated or substituted with prescribed fire. Maintaining the quality of KNC's beech-maple forests, will therefore require the control of invasive plant and animal species.

The effects of overabundant deer on forest ecosystems are numerous, and especially apparent in forests with a diverse herbaceous component. The most recent aerial estimate of the KNC deer herd, done in February 2005, was 107 deer, or 57 deer per square mile (J. Wright, pers. comm.). Waller and Alverson (1997) found that herbaceous plants may constitute up to 87% of a deer's summer diet. The detrimental effects of deer browse on herbaceous plants are varied and include gender modification of hermaphroditic species (Ruhren and Handel 2000), reduced flowering (Webster et al. 2001), and reduced overall abundance of forest herbs (Fletcher et al. 2001). Perhaps no other species is more prone to deer predation than *Trillium grandiflorum*. It is becoming increasingly rare to find a flowering stem, especially in comparison to its historical abundance on the property (R. Adams, pers. comm.).

Small wetlands are found within beech-maple forest, including seeps and vernal pools. Seeps within a forest create a unique wetland microhabitat within a drier ecosystem. These are especially apparent in the forest of the south property (C3), where much of the southeastern slope is saturated with seeps and the vegetation that accompanies them: *Symplocarpus foetidus* (skunk cabbage), *Laportea canadensis* (wood nettle), *Hydrophyllum appendiculatum* (great waterleaf), *Collinsonia canadensis* (richweed) and some impressive populations of *Asarum canadense* (wild ginger). These comprise a "sub-community" similar in many ways to a southern hardwood swamp (Kost et al. 2007). A hanging spring along the Beech Maple trail in Cooper's Glen (C1) is another fine example. The contrast of water bubbling out of the ground of an upland forest, supporting such obligate wetland species as *Caltha palustris* (marsh marigold), is striking.

Rare species associated with beech-maple forest at KNC include the vascular plants, *Liparis liliifolia* and *Carex frankii*; the mollusk, watercress snail (*Fontigens nickliniana*); the birds, cerulean warbler, hooded warbler, and Cooper's hawk; and the reptiles, Blanding's, spotted, and eastern box turtle.

Esker

An esker is an ice-contact feature derived from glacial meltwater flowing underneath an existing glacier, thus depositing till in a long, sinuous formation. The KNC esker exhibits deposition of soils with a larger grain-size (sand and gravel) that is the outcome of the way in which an esker is formed. This is unique at KNC, where upland soils are typically loamy (Austin 1979). The esker supports plants and natural communities that contrast to those in the surrounding landscape, both in its forested portion west of Westnedge Ave. (C4) and the old-field portion to the east (O3) (Figure 1). The esker cuts through primarily beech-maple forest and supports a red and black oak dominated forest, including herbaceous species such as *Chimaphila maculata* (spotted wintergreen), *Danthonia spicata* (poverty grass), *Solidago nemoralis* (old-field goldenrod), *Leptoloma cognatum* (fall witchgrass), *Anemone virginiana* (tall thimbleweed) and *Pedicularis canadensis* (wood betony) that would not be expected in beech-maple forest. Hanes and Hanes (1947) also collected *Carex leavenworthii*, a rare adventive sedge, "in gravelly sandy soil four miles north of Kalamazoo in Section 28, Cooper Twp," presumably along the esker. In late June 2008, Ryan Colliton of KNC photographed a few stems of *Platanthera lacera* along the esker in an area that was recently cleared of dense shrub cover (Figure 16).

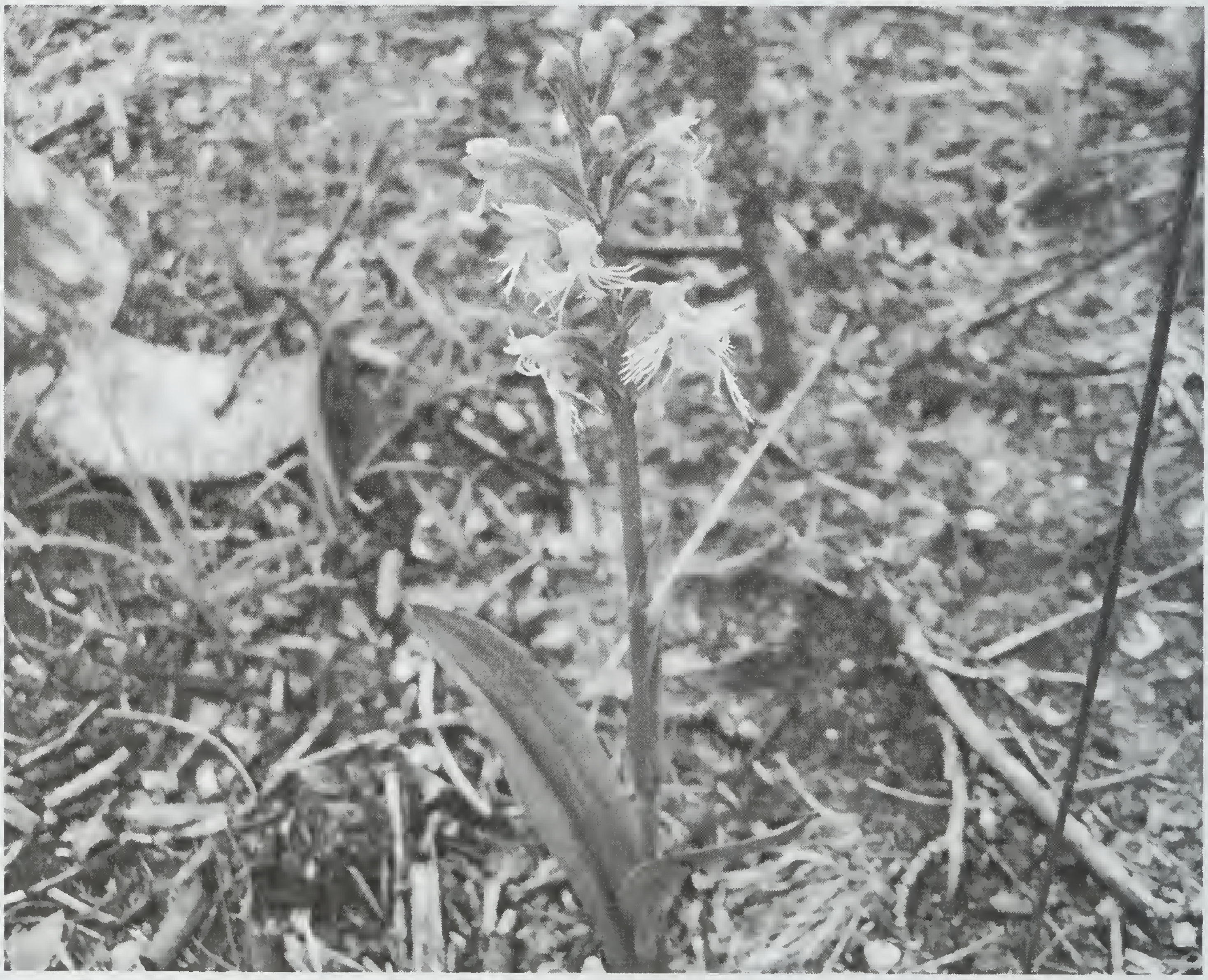

FIGURE 16. *Platanthera lacera* (ragged fringed orchid) along esker (O3) adjacent to East Fen (S1), appearing after extensive thinning of woody vegetation. Photo by Ryan Colliton.

DISTURBED

Various disturbed or early-successional land cover types occur at KNC. They are generally dominated by exotic species and low in plant species richness, but frequently support significant animal populations, included both migrating and breeding birds, and a diversity of insects.

Gravel and sand mines

Gravel and sand mines cover approximately 61 acres (25.5 hectares) at KNC. A large gravel pit (38 acres), acquired by KNC in 1990, runs parallel to the Kalamazoo River in the eastern portion of the property (G). It is dominated by *Centaurea maculosa* (spotted knapweed), *Arrhenatherum elatius* (tall oatgrass), *Bromus inermis* (smooth brome), *Melilotus alba* (white sweet clover), and *Catalpa speciosa* (northern catalpa). *Fraxinus americana, F. pensylvanica, Ulmus americana,* and *Acer saccharum* are invading from surrounding mesic and floodplain forests. *Carex pedunculata*, a species of mesic forests, is also found here (Figure 17), along with many of the typical beech-maple forest species along the margins of the gravel pit. Because droughty soils are uncommon on the property, the

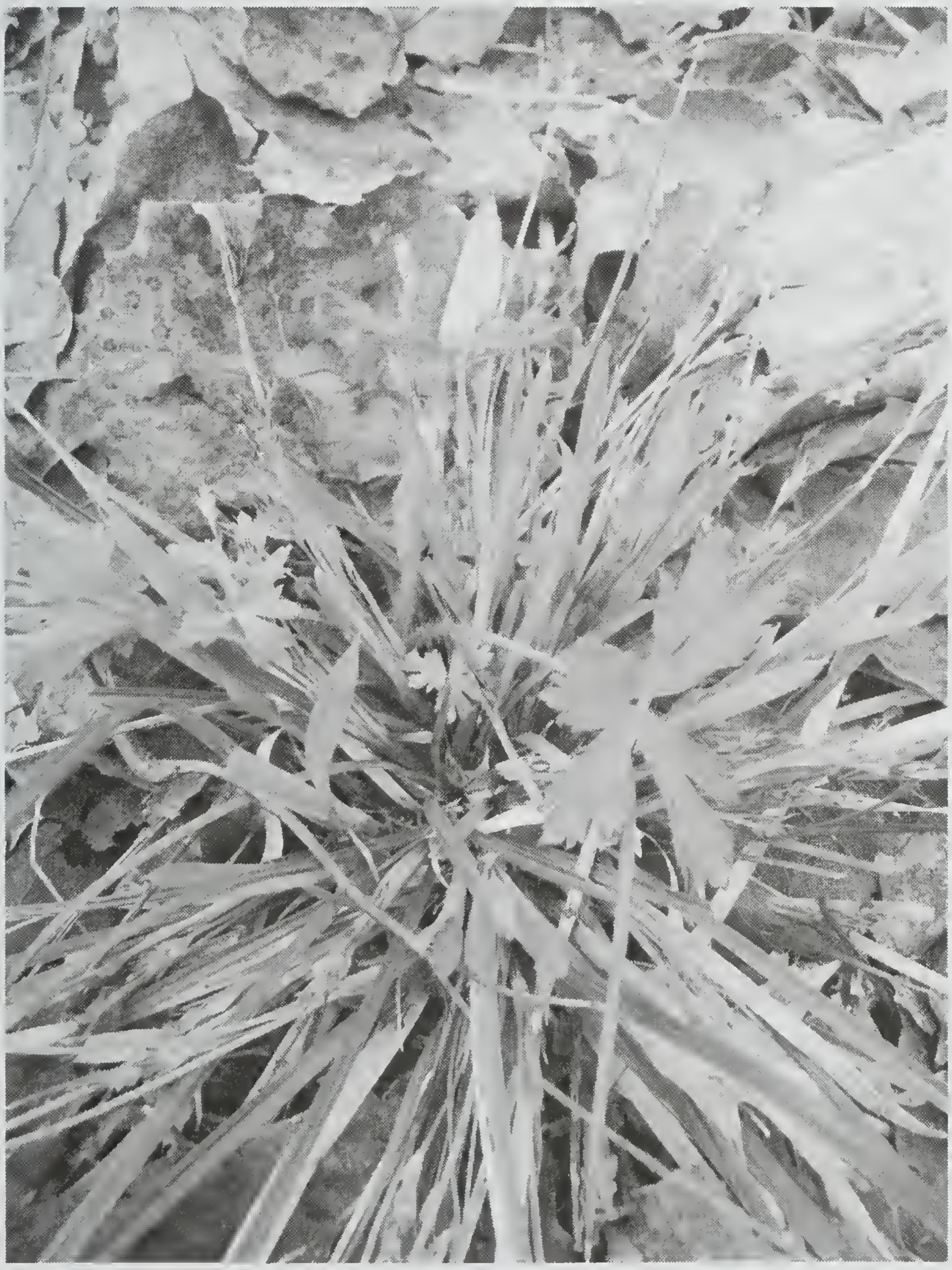

FIGURE 17. *Carex pedunculata* (sedge), in beech-maple forest (C2) adjacent to gravel pit (G).

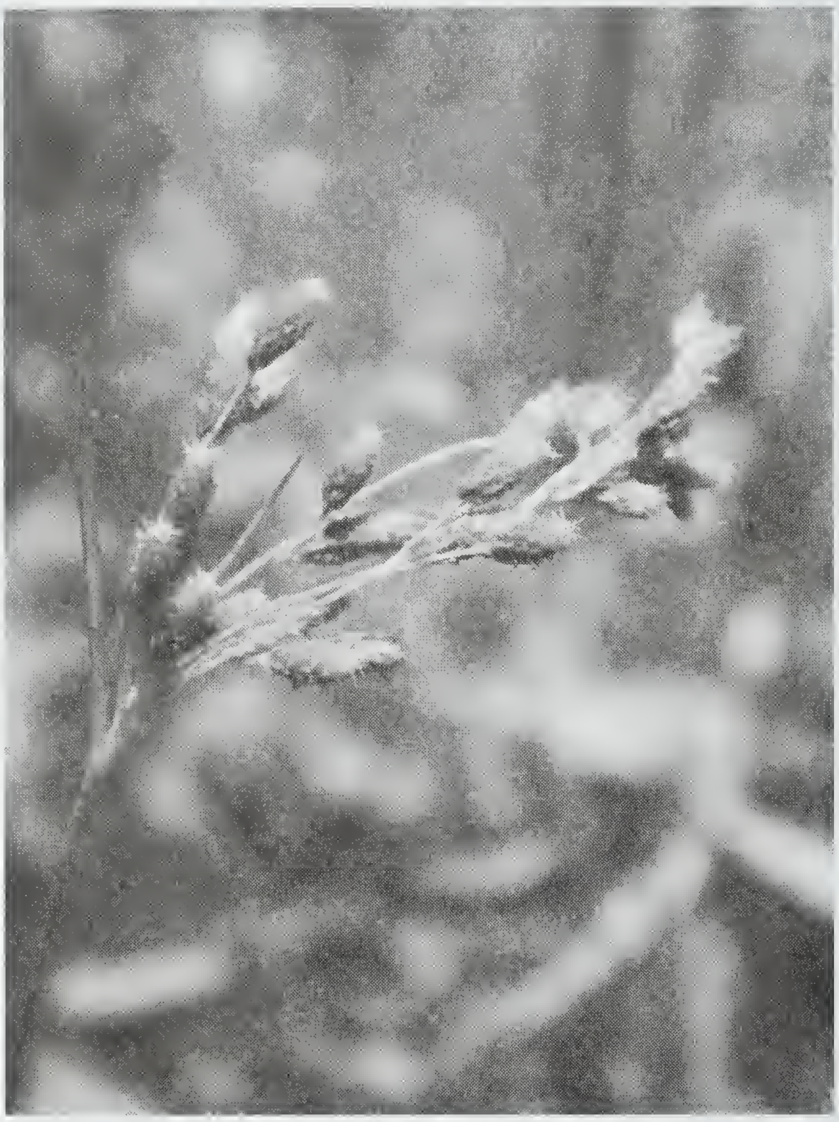

FIGURE 18. *Scirpus pendulus* (pendulous bulrush), in seepy channel in old sand mine (U4).

gravel pit provides the only station for *Asclepias verticillata* and one of the few for *Asclepias tuberosa.*

The city of Kalamazoo held a lease on a sand mine at KNC until 2003, a 23-acre inholding along the slopes north of Trout Run and west of Westnedge Avenue (U4). The apparent dominant is *Centaurea maculosa*, but *Bromus inermis, Populus grandidentata* (big-toothed aspen), *Crataegus* spp. (hawthorn), *Cornus foemina* ssp. *racemosa* (gray dogwood), *Aster pilosus* and many weedy species of dry, disturbed sites are also common. The droughtiness does provide for the only station at KNC for *Monarda punctata* (horsemint). A few chalky gravel ponds provide for some interesting microhabitats, supporting species such as *Juncus canadensis* (Canadian rush), *J. brachycephalus* (short-fruited rush), and *Equisetum hyemale* (scouring rush). A seepy slope also supports the only KNC station for *Scirpus pendulus* (pendulous bulrush) (Figure 18).

Old-fields

Old-fields occur at KNC over about 101 acres (42 hectares) in various stages of succession and site history (e.g., hayfield, logged forest). These range from domination by European cool-season grasses such as *Bromus inermis*, *Poa pratensis* (Kentucky bluegrass), *Dactylis glomerata* (orchardgrass), and *Phleum pratense* (timothy) to upland thicket habitat dominated by *Rhus typhina* (staghorn sumac), *Cornus foemina* ssp. *racemosa, Populus* spp. (hybrid poplar), or *Catalpa speciosa*. Invasion from surrounding beech-maple forest is similar to

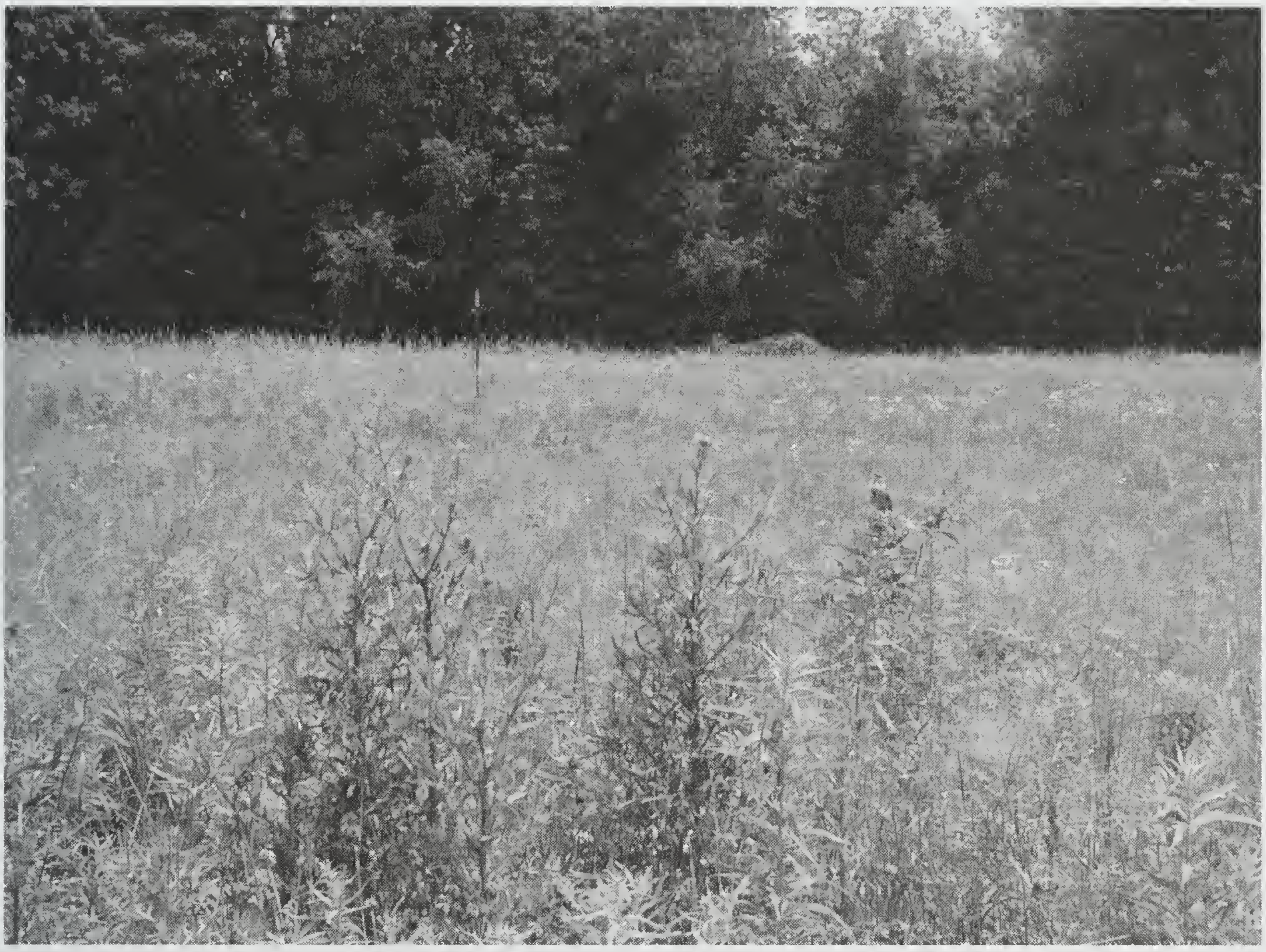

FIGURE 19. Song sparrow (*Melospiza melodia*), singing in bull thistle (*Cirsium vulgare*) in hayfield (H5).

the gravel pit. Old-fields provide the only stations for a number of interesting colonizing species, including *Oenothera laciniata* (ragged evening primrose), *Arabis glabra* (tower mustard), and *Lobelia inflata* (Indian tobacco), as well as supporting a few somewhat conservative species such as *Agropyron trachycaulum* (slender wheatgrass), *Monarda fistulosa* (wild bergamot), *Desmodium paniculatum* (panicled tick-trefoil), *Asclepias tuberosa,* and the sedges *Carex annectens, C. albursina, C. leptonervia, C. tribuloides,* and *C. radiata.*

Hay fields

A few hay fields are maintained at KNC to provide forage for farm animals on site. While the floristic diversity is typically low, they provide habitat for breeding grassland birds such as horned lark (*Eremophila alpestris*), eastern meadowlark (*Sturnella magna*), bobolink (*Dolichonyx oryzivorus*), sedge wren (*Cistothorus platensis*) and song sparrow (*Melospiza melodia*) (Figure 19).

Railroad

A railroad bisects the eastern side of the KNC property, between the gravel pit and the Kalamazoo River (Figures 1, 2). In addition to typical weeds of railbeds such as *Chaenorhinum minus* (dwarf snapdragon) and *Euphorbia maculata* (nodding spurge), margins of the railroad support plants typical of the communities through which it passes, including beech-maple forest and southern floodplain forest. There are also some interesting sedge-dominated seepage areas (e.g., *Carex hystericina*), and a few species less tolerant of shade occur here, including *Monarda fistulosa* and *Oenothera biennis* (common evening primrose).

Floristic Quality Assessment and Habitat Corridors

The Floristic Quality Assessment is by no means a definitive determination of the quality of a site (Herman et al. 2001). However, it can be the first step toward deciding the course a land manager may wish to take. If the index is 35 or higher, this is an indication of a valuable community with species of high conservatism (Herman et al. 2001). Other factors can then be considered to determine the need for further study and the most appropriate management choices. Compartments with FQIs above 35 are clustered along the course of Trout Run (C1–4, E1–2, F3, S1, S3) and the Kalamazoo River (F1–2), forming an exceptional habitat corridor (see Figure 1, Table 1). Furthermore, the protection of these communities is both feasible and important, especially the wetlands along the course of Trout Run (e.g., S1, S3, E1–2) and the Kalamazoo River, all of which scored high in floristic quality. By extension, the protection of the surrounding forests (C1–5), most of which are of high floristic quality, is important. Together, this corridor comprises an association of floristically and ecologically important upland and wetland communities. Such corridors and the large contiguous area of high quality habitat they provide offer an example of the benefits of landscape-scale preservation, opportunities for which are greatly diminished in southern Michigan.

CONCLUSIONS

A diversity of species and communities

Given the abundance and variety of data collected on plants and natural communities during this study, three useful conclusions can be drawn: 1) a successional trajectory can be anticipated for the natural communities and management can be guided based on these assumptions; 2) a baseline for species composition, community structure and other factors exists so that, in the future, the effects of land management decisions can be analyzed based upon how these measurable factors change; and 3) an understanding of what species and communities are present on the property, matched with an understanding of the landscape context in which these communities occur, should provide a better idea of which communities to restore, what to reconstruct and what to leave alone.

Implications for management, restoration and research

Despite the extensive plant and animal migrations associated with the retreat of the Wisconsinan glaciation, the past 12,000 years have seen relatively slow changes in the natural land cover until the mechanization of the human race facilitated rapid change (Berkes 2004). In North America, the Native Americans impacted the landscape on a large scale before European settlement, such as through intentional wildfires (Chapman 1984; Curtis 1959), but rarely did they impact entire landscapes in ways as dramatic as we see today, with the wholesale removal of substrates and covering of surfaces with impermeable concrete.

Many natural communities at KNC have maintained exceptional structure, processes, and native species diversity within the larger context of landscape alteration. They should be highly valued, protected, studied, and experienced as components of the natural heritage of southwest Michigan. Other communities show apparent and persistent signs of disturbance, both in the soil and the biota as a whole. Given limited available resources, these communities cannot and should not be given the same protection as the higher quality areas. This does not mean they are without value. For example, even if plant diversity is low and structure is minimal, many important bird species may still utilize these habitats (e.g., hay fields and old-fields), as birds and other animals require a diversity of intermediate and early successional land cover types. Also, some habitats may require only the restoration of a natural process like fire or flooding to be revitalized into a higher quality community. Other types of landcover (e.g., those under tillage [T1 and T2], the gravel pit [G]) are wholly disturbed and do not represent the historical landscape in any way. These provide ample opportunity for the reconstruction of communities not currently well-represented on the KNC landscape such as prairie or savanna. This may be a long-term process, beginning by restoring soil structure. It also provides an opportunity for research on restoration techniques and may provide clues to poorly understood ecological concepts.

End Note

During the spring following the conclusion of this study, a contractor was hired to plant a large prairie reconstruction in an agricultural field (T1) and surrounding hay field (H2) and old-fields (O7, O5, U2). A total of 144 acres of prairie was established in 2005 and 2006. Grassland birds occupied the available habitat almost immediately. As of June 2007, the following grassland bird species have been observed nesting in the new prairie, with number of breeding pairs observed in parentheses: bobolink (8), vesper sparrow (11), savannah sparrow (14), horned lark (11), eastern meadowlark (8), State special-concern grasshopper sparrow (9) and dickcissel (18), and state-threatened Henslow's sparrow (6) (Kalamazoo Nature Center Research Dept., unpublished data).

ANNOTATED CHECKLIST (Appendix 2)

Abundance of each species and infra-specific taxon is indicated as *rare, uncommon, occasional, common, locally common, abundant,* or *locally abundant* (see *Methods*) within the range of stated habitats. Exotic species are indicated in bold. Previous records not observed during this study but likely extant are indicated by an asterisk. General habitat is indicated for each species and infraspecific taxon. If a taxon was found in only a single compartment, that compartment is indicated in parentheses. More information is included about where a species was observed when relevant and known.

Most species and infra-specific taxa represented at the KNC herbarium are by historical collectors (1959–1991) and are indicated by name of the most recent collector; no collection numbers were given for these specimens. Each of these collectors was limited to a one- or two-year collecting period (Appendix 2). All collection numbers represent a collection made by the author. These have been submitted to the Western Michigan University Hanes Herbarium (WMU).

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APPENDIX 1.

NOTES TAKEN BY THE HANES' ON COOPER'S GLEN

Hanes and Hanes (1947) recorded detailed information about exceptional collecting sites in Kalamazoo County in a large bound tome that is currently housed in the Hanes Herbarium at WMU. The herbarium was established in part to house the many collections made by the Hanes' in the first half of the 20th century; this large notebook was intended as a companion. One page contains a list of plants found at Cooper's Glen. A total of 57 names are given below **as written** in the Hanes' notebook (synonyms are given in parentheses). *N.B.- the columns do not correspond to one another.*

List of Plants Found at Cooper's Glen Apr. 30 '36

Spring Beauty
Dutchman's Breeches
Squirrel Corn
Pepper and Salt
Yellow Adder's Tongue
Blue Eyed Mary
Golden Saxifrage
Marsh Marigoid
Skunk Cabbage
Acute and Round-leaved Hepatica
Blue Ash
Butternut
Early Meadow Rue
Solomon Seal (Smaller)
Christmas Fern
Marginal Shield Fern
Spice Bush
Red Berried Elder

Ranunculus septentrionalis (R. hispidus)
Ranunculus abortivus
Isopyrum biternatum
Floerkea proserpinacoides
Anemone quinquefolia
Trillium grandiflorum
Phlox divaricata
Allium tricoccum
Dentaria diphylla
Dentaria laciniata
Cardamine douglassii
Carex pensylvanica
Carex plantaginea
Carex careyana
Viola canadensis
Viola papilionacea (V. sororia)
Viola compressa (V. conspersa?)
Hydrophyllum canadense
Mitella diphylla
Geranium maculatum

Other Plants Found at Cooper's Glen

Fragile Bladder Fern
Ostrich Fern
Luzula saltuensis (L. acuminata)
Quercus muehlenbergii
Polygonum cuspidatum
Hypericum ascyron
Agrimonia mollis (A. pubescens)
Botrychium obliquum (B. dissectum)
Carex leavenworthii
Aster junceus (A. borealis)

Carduus crispus (Cirsium sp.?)
Sisyrinchium gramineum (S.angustifolium)
Carex grisea (C. amphibola)
Carex hitchcockiana
Carex laxiflora
Saururus cernuus
Carex rostrata
Centaurea maculosa

APPENDIX 2. ANNOTATED CHECKLIST OF THE VASCULAR FLORA OF THE KALAMAZOO NATURE CENTER.

Collection numbers are all Tyler Bassett, except for Kenoyer (= Leslie A Kenoyer) and Hanes = (Clarence and Florence Hanes). "*" indicates species collected prior to but not observed during the current study. Non-native species in bold. List of collectors for specimens housed at Kalamaoo Nature Center herbarium (no collection numbers): Ray Adams, Jr. (1971), Jahanguir Assadi, (1978), M.R. Betz (1990-91), D. Broersma (1959), F. E. Chape (1959), Louis F. Conde (1981-83), Susan Gibson (1963), Richard D. Kelley (1959), Marian Kummer (1971), Dee LaBatt (1959), Mary K. Lewis (1959), Mary Meininger (1968), Susan Norris (1968), Judy Prentice (1968), Jon Shoemaker (1959), Arlene Shub (1978), Ellsworth Starring (1959), E.B. Walter (1963), Laurie Weston (1971).

Latin Name	Common Name	Habitat (Compartments)	Abundance	Collectors
PTERIDOPHYTES				
FERNS				
Aspleniaceae (Spleenwort Family)				
Asplenium platyneuron (L.) B.S.P.	Ebony spleenwort	old-fields, disturbed areas, thickets, young forests	common	*Conde*
Dennstaedtiaceae (Bracken Family)				
Pteridium aquilinum (L.) Kuhn	Bracken fern	roadside on gravelly hilltop near South Property (C3)	uncommon	*Adams*
Dryopteridaceae (Wood Fern Family)				
Athyrium filix-femina (L.) Roth	Lady fern	beech-maple and floodplain forests, edges of swamps	occasional	*Conde*
Cystopteris fragilis (L.) Bernh.	Fragile fern	Cooper's Glen (C1), floodplain forest (F1/2)	uncommon	*Conde*
Deparia acrostichoides (Swartz) M. Kato	Silvery spleenwort	swale in beech-maple forest (C3), floodplain forest (F2)	uncommon	*Conde*
Diplazium pycnocarpon (Sprengel) M. Broun	Narrow-leaved spleenwort	swale in beech-maple forest (C3)	uncommon	*Conde*
Dryopteris carthusiana (Vill.) H.P. Fuchs	Spinulose woodfern	forested habitat of all kinds	common	*Conde*
**Dryopteris celsa (Wm. Palmer) Knowlt., Palmer & Pollard ex Small (T)*	Log Fern	floodplain forest (F1)	rare	*no collection*
Dryopteris clintoniana (D.C. Eat.) Dowell	Clinton's woodfern	floodplain forest (F1), thicket (U1)	uncommon	*Conde*
Dryopteris cristata (L.) Gray	Crested shield fern	swampy thickets (F3, I1)	uncommon	*Conde*
Dryopteris goldiana (Hook. ex Goldie) Gray	Goldie's woodfern	swale in beech-maple forest (C3), floodplain forest (F2)	uncommon	*Conde*
Dryopteris intermedia (Muhl. ex Willd.) Gray	Evergreen woodfern	edge of shrub swamp (E2)	uncommon	*4173*
Dryopteris marginalis (L.) Gray	Marginal woodfern	edge of small wet depression in beech-maple forest (I3)	rare	*Conde*
Onoclea sensibilis L.	Sensitive fern	wet and moist areas throughout	abundant	*Gibson*
Polystichum acrostichoides (Michx.) Schott	Christmas fern	beech-maple and floodplain forests, edges of swamps	occasional	*Adams*
Ophioglossaceae (Grape-fern Family)				
Botrychium dissectum Spreng.	Cut-leaved grape-fern	disturbed beech-maple forests	rare	*Conde*
Osmundaceae (Flowering-fern Family)				
Osmunda cinnamomea L.	Cinnamon fern	swampy thickets	occasional	*Adams*
Osmunda regalis L.	Royal fern	swampy thickets	occasional	*Adams*

Pteridaceae (Maidenhair Fern Family)				
Adiantum pedatum L.	Maidenhair fern	beech-maple and floodplain forests	uncommon	*Adams*
Thelypteridaceae (Marsh Fern Family)				
Thelypteris palustris Schott	Marsh fern	sedge meadows throughout	common	*Adams*
FERN ALLIES				
Equisetaceae (Horsetail Family)				
Equisetum arvense L.	Common horsetail	moist forest borders and sedge meadows	occasional	*Conde*
**Equisetum fluviatile L.*	Water horsetail	floodplain forest (F1)	rare	*Conde*
Equisetum hyemale L.	Scouring rush	disturbed, moist gravelly soil throughout, as along railroad	occasional	*Betz*
Lycopodiaceae (Clubmoss Family)				
Diphasiastrum complanatum L.	Ground-cedar	disturbed beech-maple forest (C5)	uncommon	*Walter*
Huperzia lucidula (Michaux) Trevisan	Shining clubmoss	dry knoll in Source Marsh (E2)	rare	*Conde*
Lycopodium clavatum L.	Running ground-pine	dry knoll in Source Marsh (E2)	rare	*Conde*
Lycopodium obscurum L.	Ground-pine	dry knoll in Source Marsh (E2)	rare	*Conde*
Selaginellaceae (Spikemoss Family)				
Selaginella eclipes Buck	Selaginella	edge of hummocks in sedge meadow	occasional	*Conde*
GYMNOSPERMS				
Cupressaceae (Cypress Family)				
Juniperus virginiana L.	Red-cedar	old-fields and shrub thickets	occasional	*Conde*
Pinaceae (Pine Family)				
Larix laricina (Du Roi) K. Koch	Tamarack	edges of sedge meadow	uncommon	*Conde*
ANGIOSPERMS				
Aceraceae (Maple Family)				
Acer negundo L.	Box elder	disturbed and successional forest	common	*Conde*
Acer nigrum Michx. f.	Black maple	in moister soil near streams and disturbed areas in beech-maple forest	occasional	*3192*
Acer platanoides L.	Norway maple	Cooper's Glen adjacent to gravel pit (C2)	uncommon	*no collection*
Acer rubrum L.	Red maple	beech-maple and successional forest, various wetlands	occasional	*Conde*
Acer saccharinum L.	Silver maple	wide bottoms of Kalamazoo River, shrub swamps	common	*7123*
Acer saccharum Marsh.	Sugar maple	throughout in uplands	abundant	*Conde*
Acoraceae (Sweet-flag Family)				
Acorus calamus L.	Sweet-flag	wetter sedge meadows along Kalamazoo River	uncommon	*7135*
Alismataceae (Water-plantain Family)				
Alisma plantago-aquatica L.	Water-plantain	shrub swamp in a "lobe" of Source Marsh (E2)	rare	*7034*
Sagittaria latifolia Willd.	Common arrowhead	emergent marsh along streams	common	*Gibson*
Amaranthaceae (Amaranth Family)				
**Amaranthus albus L.*	Tumbleweed	disturbed areas	rare	*Conde*
****Amaranthus blitoides S. Watson***	Amaranth	disturbed areas	rare	*LaBatt*

Latin Name	Common Name	Habitat (Compartments)	Abundance	Collectors
Amaranthus retroflexus L.	Pigweed	disturbed areas	rare	*Conde*
Anacardiaceae (Sumac Family)				
Rhus glabra L.	Smooth sumac	gravel pit (G)	rare	*Conde*
Rhus typhina L.	Staghorn sumac	throughout in successional uplands	common	*Walter*
Toxicodendron radicans (L.) Kuntze	Poison-ivy	throughout	abundant	*Conde*
Toxicodendron vernix (L.) Kuntze	Poison sumac	sedge meadows	occasional	*Conde*
Annonaceae (Custard-apple Family)				
Asimina triloba (L.) Dunal	Pawpaw	canopy openings in beech-maple and floodplain forest: Cooper's Glen (C1) and Kalamazoo River floodplain (F1)	locally abundant	*Conde*
Apiaceae (Carrot Family)				
Angelica atropurpurea L.	Angelica	sedge meadow and openings in shrub-carr	occasional	*Assadi/Shub*
Berula erecta (Huds.) Coville (T)	Water-parsnip	mucky edges of Trout Run in sedge meadow	locally common	*3200*
Cicuta bulbifera L.	Water hemlock	sedge meadow and shrub-carr	occasional	*Conde*
Cicuta maculata L.	Water hemlock	sedge meadow, shrub-carr, and swamp forest	uncommon	*LaBatt*
Cryptotaenia canadensis (L.) DC.	Honewort	mostly wetter forests	occasional	*Assadi/Shub*
Daucus carota L.	Queen-Anne's-lace	old-fields and other disturbed areas	common	*Assadi/Shub*
Erigenia bulbosa (Michx.) Nutt.	Harbinger-of-spring	beech-maple forest in Cooper's Glen (C1) and floodplain forest (F2)	uncommon	*Prentice*
Osmorhiza claytonii (Michx.) C.B. Clarke	Hairy sweet-cicely	beech-maple forest	uncommon	*Assadi/Shub*
Osmorhiza longistylis (Torr.) DC.	Smooth sweet cicely	beech-maple forest	uncommon	*Assadi/Shub*
Oxypolis rigidior (L.) Raf.	Cowbane	sedge meadows throughout	occasional	*Adams*
Sanicula canadensis L.	Black snakeroot	beech-maple forest in Cooper's Glen (C1)	uncommon	*Gibson*
Sanicula gregaria Bickn.	Black snakeroot	beech-maple forest in Pioneer Woods (C4) and floodplain forest	occasional	*Assadi/Shub*
Sanicula trifoliata Bickn.	Black snakeroot	high-quality beech-maple and floodplain forest	occasional	*Conde*
Sium suave Walt.	Water-parsnip	ponded area in floodplain forest (F2)	rare	*no collection*
Apocynaceae (Dogbane Family)				
Apocynum androsaemifolium L.	Spreading dogbane	open sites on sandy soil as near gravel pit and railroad	uncommon	*Assadi/Shub*
Apocynum cannabinum L.	Indian hemp	open wetlands and disturbed sites on mesic soil	common	*Conde*
Vinca minor L.	Periwinkle	roadsides and near old homesites	uncommon	*no collection*
Aquifoliaceae (Holly Family)				
Ilex verticillata (L.) Gray	Michigan holly	shrub swamp in a "lobe" of Source Marsh (E2)	rare	*Conde*
Araceae (Arum Family)				
Arisaema dracontium (L.) Schott	Green dragon	Kalamazoo River floodplain	uncommon	*Photo*
Arisaema triphyllum (L.) Schott	Jack-in-the-pulpit	forested habitat of all kinds	abundant	*Betz*
Peltandra virginica (L.) Schott	Arrow-arum	emergent marsh along Kalamazoo River	uncommon	*Conde*
Symplocarpus foetidus (L.) Salisb. ex Nutt.	Skunk-cabbage	saturated soil	abundant	*Kelley*

Araliaceae (Ginseng Family)				
Aralia nudicaulis L.	Wild sarsaparilla	gravelly bank along Kalamazoo River (F2)	rare	*7122*
Hedera helix L.	English ivy	disturbed area near Kalamazoo River (F2)	rare	*no collection*
Panax trifolius L.	Dwarf ginseng	alluvial soil along Trout Run (F3)	rare	*Meininger*
Aristolochiaceae (Birthwort Family)				
Asarum canadense L.	Wild-ginger	Moist beech-maple forest and floodplain forest	occasional	*Assadi/Shub*
Asclepiadaceae (Milkweed Family)				
Asclepias incarnata L.	Swamp milkweed	sedge meadows throughout	common	*Walter*
Asclepias syriaca L.	Common milkweed	Throughout in open habitats	abundant	*Gibson*
Asclepias tuberosa L.	Butterfly-weed	old-fields and gravel pit (G)	uncommon	*Betz*
Asclepias verticillata L.	Whorled milkweed	gravel pit (G)	rare	*7126*
Asteraceae (Aster Family)				
Achillea millefolium L.	Yarrow	primarily in old-fields and upland shrub thickets	occasional	*Assadi/Shub*
Ambrosia artemisiifolia L.	Common ragweed	hayfields and disturbed margins of old-fields	occasional	*Conde*
Ambrosia trifida L.	Giant ragweed	poplar planting (A1) and upland shrub thickets	uncommon	*Adams*
**Anaphalis margaritacea (L.) Benth.*	Pearly everlasting	upland shrub thicket (U1)	uncommon	*Conde*
**Antennaria neglecta Greene*	Cat's foot		uncommon	*Betz*
Antennaria parlinii Fern.	Smooth pussytoes	successional openings in sandy soil in beech-maple forest.	uncommon	*Assadi/Shub*
Anthemis arvensis L.	Field chamomile	hayfield (H4) and trails	uncommon	*Conde*
Arctium minus Bernh.	Common burdock	disturbed areas and trails throughout	abundant	*LaBatt*
Artemisia vulgaris L.	Mugwort	disturbed areas, especially near trails	locally common	*7029*
Aster borealis (Torr. & Gray) Prov.	Northern bog-aster	sedge meadows	occasional	*3328*
Aster cordifolius L.	Arrow-leaved aster	beech-maple forest and old-fields	common	*Conde*
Aster firmus Nees	Swamp aster	sedge meadows	locally abundant	*3301*
Aster lanceolatus Willd.	Eastern lined aster	sedge meadows throughout	occasional	*Conde*
Aster lateriflorus (L.) Britt.	Side-flowering aster	throughout in all habitats	abundant	*Conde*
Aster macrophyllus L.	Big-leaved aster	beech-maple and floodplain forest	occasional	*Conde*
Aster novae-angliae L.	New England aster	sedge meadow: Source Marsh (E1)	uncommon	*Conde*
Aster ontarionis Wieg.	Ontario aster	beech-maple forest	occasional	*3331, 3348*
Aster pilosus Willd.	Hairy aster	old-fields and hayfields, especially in sandy soils	common	*Conde*
Aster praealtus Poir. (SC)	Willow aster	sedge meadow (S1, S2)	uncommon	*3303*
Aster puniceus L.	Hairy swamp aster	sedge meadows throughout	locally abundant	*Conde*
Aster shortii Lindl.	Short's aster	beech-maple forest, floodplain forest near Kalamazoo River, and adjacent habitats	occasional	*Conde*
Bidens cernua L.	Nodding bur-marigold	shallow water in sedge meadow and shrub swamp	occasional	*Conde*
Bidens comosus	Swamp tickseed	West Fen (S3)	uncommon	*4378*
Bidens connatus Muhl. ex Willd.	Purple-stemmed tickseed	S2	locally common	*no collection*
**Bidens frondosa L.*	Beggar's tick		uncommon	*Walter*

Latin Name	Common Name	Habitat (Compartments)	Abundance	Collectors
Centaurea maculosa auct. non Lam.	Spotted bluet	old-fields and other disturbed areas	common	*Gibson*
Chondrilla juncea L.	Skeleton-weed	old-field (O7)	rare	*Conde*
Chrysanthemum leucanthemum L.	Ox-eye daisy	old-fields and other disturbed areas	common	*Betz*
Cichorium intybus L.	Chicory	field margins and roadsides	occasional	*no collection*
Cirsium arvense (L.) Scop.	Canadian-thistle	old-fields and a sedge meadow (E5)	occasional	*Conde*
Cirsium muticum Michx.	Swamp-thistle	sedge meadows throughout	occasional	*Adams*
Cirsium vulgare (Savi) Ten.	Bull-thistle	old-fields and disturbed forest edges	occasional	*Conde*
Conyza canadensis (L.) Cronq.	Horseweed	recently disturbed soil	common	*LaBatt*
Crepis capillaris (L.) Wallr.	Hawk's beard	old-fields and trail edges	occasional	*Conde*
Erechtites hieracifolia (L.) Raf. ex DC.	Fireweed	recently disturbed soil	uncommon	*Conde*
Erigeron annuus (L.) Pers.	Annual fleabane	old-fields, disturbed areas, thickets, young forests	common	*Betz*
Erigeron philadelphicus L.	Marsh fleabane	sedge meadows	uncommon	*Conde*
Erigeron pulchellus Michx.	Robin's plantain	sedge meadows	uncommon	*Gibson*
Erigeron strigosus Muhl. ex Willd.	Daisy fleabane	disturbed areas	occasional	*Assadi/Shub*
Eupatorium maculatum L.	Joe-pye-weed	primarly in sedge meadows	abundant	*Conde*
Eupatorium perfoliatum L.	Common boneset	sedge meadows and shrub-carr	abundant	*Walter*
Eupatorium purpureum L.	Purple joe-pye-weed	gravel banks above Kalamazoo River (G) and margin of shrub swamp (I2)	uncommon	*Gibson*
Eupatorium rugosum Houtt.	White snakeroot	beech-maple and floodplain forest	occasional	*Conde*
Euthamia graminifolia (L.) Nutt.	Grass-leaved goldenrod	open areas; old-fields and sedge meadows	common	*Conde*
Gnaphalium macounii Greene	Clammy cudweed	open sandy slopes	occasional	*Conde*
Helianthus decapetalus L.	Pale sunflower	moist beech-maple forest	occasional	*Adams*
Helianthus giganteus L.	Tall sunflower	sedge meadows throughout	common	*Conde*
**Helianthus strumosus L.*	Pale-leaved sunflower	north floodplain of Kalamazoo River (F1)	occasional	*Conde*
Helianthus tuberosus	Jerusalem artichoke	roadsides and near old homesites	occasional	*no collection*
Hieracium aurantiacum L.	Orange hawkweed	old-fields and other disturbed areas	occasional	*Assadi/Shub*
Hieracium caespitosum Dumort.	King-devil	old-fields and other disturbed areas	occasional	*Assadi/Shub*
Hieracium pilosella L.	Mouse-ear hawkweed	upland shrub thicket (U4)	uncommon	*Gibson*
Hieracium piloselloides Vill.	Glaucous king-devil	U4	uncommon	*no collection*
Hypochaeris radicata L.	Spotted cat's-ear	U4	uncommon	*no collection*
**Krigia biflora (Walt.) Blake*	Cynthia	beech-maple forest: Pioneer Woods (C4)	rare	*Assadi/Shub*
Lactuca canadensis L.	Tall lettuce	openings in beech-maple forest and disturbed areas	occasional	*Gibson*
Lactuca serriola L.	Prickly lettuce	disturbed areas	uncommon	*Conde*
**Prenanthes alba L.*	White lettuce	beech-maple forest	rare	*Conde*
Prenanthes altissima L.	Tall white lettuce	beech-maple forests	occasional	*Conde*
Rudbeckia fulgida Ait.	Brown-eyed Susan	sedge meadow: East Fen (S1)	rare	*Gibson*
Rudbeckia hirta L.	Black-eyed Susan	old-fields, shrub thickets, and sedge meadows	occasional	*Betz*

Rudbeckia laciniata L.	Cut-leaved coneflower	forested floodplains and shrub-carr	occasional	*Adams*
Rudbeckia triloba L.	Three-lobed coneflower	gravelly ridge above Kalamazoo River floodplain	rare	*Photo*
Senecio aureus L.	Golden ragwort	shrubby wet areas in general	locally abundant	*Conde*
Solidago altissima L.	Tall goldenrod	open habitats of all kinds	abundant	*Adams*
Solidago caesia L.	Blue-stemmed goldenrod	forested habitat of all kinds	occasional	*Conde*
Solidago canadensis L.	Canada goldenrod	old-fields, shrub thickets, and sedge meadows	occasional	*Adams*
Solidago flexicaulis L.	Broad-leaved goldenrod	moist beech-maple and floodplain forests	occasional	*Adams*
Solidago gigantea Ait.	Late goldenrod	Kalamazoo River floodplain (F1) and edges of sedge meadow	occasional	*Adams*
Solidago juncea Ait.	Early goldenrod	sandy old-fields and shrub thickets	occasional	*LaBatt*
Solidago nemoralis Ait.	Old-field goldenrod	sandy old-fields and shrub thickets	occasional	*Adams*
Solidago ohioensis Frank ex Riddell	Ohio goldenrod	near seepages in sedge meadow: Source Marsh (E2)	uncommon	*7030, 7080*
Solidago patula Muhl. ex Willd.	Swamp goldenrod	shrub-carr and wet forests	common	*Adams*
Solidago riddellii Frank ex Riddell	Riddell's goldenrod	sedge meadows throughout	occasional	*Adams*
Solidago rigida L.	Stiff goldenrod	dry ridge above East Fen (U1)	rare	*Conde*
Solidago rugosa P. Mill.	Rough goldenrod	forested habitat of all kinds	occasional	*Adams*
Solidago speciosa Nutt.	Showy goldenrod	dry ridge above East Fen (U1)	rare	*Conde*
Solidago uliginosa Nutt.	Bog goldenrod	sedge meadow: East Fen (S1)	uncommon	*Conde*
Sonchus asper (L.) Hill	Perennial sow thistle	shrub thicket (U7)	uncommon	*Conde*
Taraxacum officinale G.H. Weber ex Wiggers	Common dandelion	everywhere	abundant	*Assadi/Shub*
Tragopogon dubius Scop.	Goat's beard	disturbed areas	uncommon	*Betz*
Tragopogon pratensis L.	Common goat's beard	disturbed areas	occasional	*Assadi/Shub*
Vernonia missurica Raf.	Missouri ironweed	old-fields, forest openings, and sedge meadows	common	*Conde*
Xanthium strumarium L.	Common cocklebur	edges of farm fields and other disturbed areas	uncommon	*4283*
Balsaminaceae (Jewelweed Family)				
Impatiens capensis Meerb.	Spotted touch-me-not	wet ground generally and adjacent uplands	common	*Betz*
Impatiens pallida Nutt.	Pale touch-me-not	beech-maple forest, especially on edges	occasional	*Conde*
Berberidaceae (Barberry Family)				
Berberis thunbergii DC.	Japanese barberry	disturbed beech-maple forests	locally common	*Betz*
Caulophyllum thalictroides (L.) Michx.	Blue cohosh	higher quality beech-maple and floodplain forests	occasional	*Assadi/Shub*
Podophyllum peltatum L.	May apple	forests and forest edges	abundant	*Betz*
Betulaceae (Birch Family)				
Alnus rugosa (Du Roi) Spreng.	Tag alder	shrub-carr in Kalamazoo River floodplain (F1)	occasional	*Conde*
Carpinus caroliniana Walt.	Blue-beech	shrub-carr, beech-maple and wet forests	locally abundant	*Conde*
Corylus americana Walt.	Hazelnut	edges of beech-maple forest, including transitions to sedge meadow	occasional	*Conde*
Ostrya virginiana (P. Mill.) K. Koch	Ironwood	beech-maple and floodplain forests	occasional	*Conde*

Latin Name	Common Name	Habitat (Compartments)	Abundance	Collectors
Bignoniaceae (Catalpa Family)				
Campsis radicans (L.) Seem. ex Bureau	Trumpet vine	disturbed beech-maple forest (C2)	rare	*no collection*
Catalpa speciosa (Warder) Warder ex Engelm.	Northern catalpa	disturbed beech-maple forest, old-fields; including a large monoculture (U2)	locally abundant	*Conde*
Boraginaceae (Borage Family)				
****Cynoglossum officinale L.***	Common hound's-tongue	disturbed areas	rare	*Broersma*
Hackelia virginiana (L.) I.M. Johnston	Beggar's lice	beech-maple and floodplain forests	occasional	*7083*
****Lithospermum arvense L.***	Redroot	edges of farm fields and other disturbed areas		*Assadi/Shub*
****Myosotis arvensis (L.) Hill***	Field scorpion-grass			*Prentice*
Myosotis scorpioides L.	Forget-me-not	mudflats along Kalamazoo River	uncommon	*Assadi/Shub*
Symphytum officinale L.	Common comfrey	upland shrub thicket (U4)	uncommon	*Conde*
Brassicaceae (Mustard Family)				
Alliaria petiolata (Bieb.) Cavara & Grande	Garlic mustard	everywhere	locally abundant	*no collection*
Alyssum alyssoides (L.) L.	Pale alyssum	disturbed sandy and gravelly soil	uncommon	*Betz*
Arabidopsis thaliana (L.) Heynh.	Mouse-ear cress	disturbed areas	uncommon	*Betz*
Arabis glabra (L.) Berhnh.	Tower mustard	edge of hayfield (H4)	rare	*Betz*
Arabis laevigata (Muhl. ex Willd.) Poir.	Smooth bank cress	margin of railroad right-of-way	rare	*Betz*
Barbarea vulgaris Ait. f.	Yellow rocket	disturbed areas	occasional	*Betz*
Berteroa incana (L.) DC.	Hoary alyssum	old-fields and hayfields, especially in sandy soils	occasional	*Betz*
Camelina microcarpa DC.	Small-fruited false flax	gravel pit (G)	rare	*no collection*
****Capsella bursa-pastoris (L.) Medik.***	Shepherd's purse	edges of farm fields and other disturbed areas		*Assadi/Shub*
Cardamine bulbosa (Schreb. ex Muhl.) B.S.P.	Spring cress	sedge meadows and shrub-carr	common	*Prentice*
Cardamine douglassii Britt.	Pink spring cress	sedge meadows and shrub-carr	common	*Conde*
Cardamine hirsuta L.	Hoary bitter cress	disturbed sandy and gravelly soil	occasional	*4019*
Cardamine pensylvanica Muhl. ex Willd.	Pennsylvania bitter cress	edge of sedge meadows in shrub-carr	uncommon	*Norris*
Dentaria diphylla Michx.	Two-leaved toothwort	higher quality beech-maple and floodplain forests	common	*Betz*
Dentaria laciniata Muhl. ex Willd.	Cut-leaved toothwort	higher quality beech-maple and floodplain forests	common	*Betz*
****Eriophila verna (L.) Besser***	Whitlow-grass	disturbed areas in sandy soil	rare	*Conde*
Hesperis matronalis L.	Dame's rocket	disturbed forest and edges	occasional	*Betz*
Lepidium campestre (L.) Ait. f.	Field cress	disturbed areas	uncommon	*Betz*
****Lepidium virginicum L.***	Pepper-grass	disturbed areas	uncommon	*Betz*
Nasturtium officinale Ait. f.	Watercress	cool springs and mucky margins of spring-fed streams	common	*Shub*
****Raphanus raphanistrum L.***	Wild radish	edge of hayfield (H4)	uncommon	*Prentice*
****Sisymbrium officinale (L.) Scop.***	Hedge mustard	edge of hayfield (H4)	uncommon	*LaBatt*
****Thlaspi arvense L.***	Penny cress	edge of hayfield (H1)	uncommon	*Betz*
Campanulaceae (Bellflower Family)				
Campanula americana L.	Tall bellflower	disturbed beech-maple forest (C2) and Kalamazoo River floodplain	occasional	*Kelley*

Campanula aparinoides Pursh	Marsh bellflower	sedge meadows throughout	common	*7079*
Lobelia cardinalis L.	Cardinal flower	wet ditch in Kalamazoo River floodplain (F1)	rare	*Photo*
Lobelia inflata L.	Indian tobacco	thickets and trails	uncommon	*Conde*
Lobelia kalmii L.	Bog lobelia	marly seep in Source Marsh (E2)	uncommon	*Conde*
Lobelia siphilitica L.	Great blue lobelia	wet ground throughout	common	*Walter*
Capparaceae (Caper Family)				
**Polanisia dodecandra (L.) DC. ssp. dodecandra*	Redwhisker clammyweed	railroad right-of-way		*Betz*
Caprifoliaceae (Honeysuckle Family)				
Lonicera dioica L.	Red honeysuckle	gravelly esker through beech-maple forest (C4)	rare	*Photo*
Lonicera maackii (Rupr.) Herder	Amur honeysuckle	disturbed edge of beech-maple forests	uncommon	*7125*
Lonicera morrowii Gray	Morrow honeysuckle	upland forests, thickets and fields; occasionally in wetlands	occasional	*7039*
Lonicera tatarica L.	Tartarian honeysuckle	upland forests, thickets and fields; occasionally in wetlands	common	*Betz*
Sambucus canadensis L.	Elderberry	sedge meadow and wet edges of beech-maple and floodplain forests	common	*Gibson*
Sambucus racemosa L.	Red-berried elder	beech-maple and floodplain forests	occasional	*Shoemaker*
Triosteum aurantiacum Bickn.	Horse-gentian	gravelly ridge above Kalamazoo River	rare	*Assadi/Shub*
Viburnum acerifolium L.	Maple-leaved arrow-wood	higher quality beech-maple forests	occasional	*Norris*
Viburnum dentatum L.	Smooth arrow-wood	beech-maple and floodplain forests	occasional	*no collection*
Viburnum lentago L.	Nannyberry	sedge meadow and shrub-carr	locally abundant	*Betz*
Viburnum opulus L. var. opulus	European highbush cranberry	disturbed areas, spreading somewhat into moist ground	occasional	*Conde*
Viburnum opulus L. var. americanum Ait.	Highbush cranberry	sedge meadow and shrub-carr	occasional	*7028, 7086*
Caryophyllaceae (Pink Family)				
Arenaria serpyllifolia L.	Thyme-leaved sandwort	upland shrub thicket (U4)	rare	*Betz*
Cerastium fontanum Baumg.	Mouse-eared chickweed	disturbed areas, especially near trails	uncommon	*Betz*
Dianthus armeria L.	Deptford pink	old-fields	uncommon	*Betz*
Saponaria officinalis L.	Bouncing Bet	disturbed areas; especially old-fields	occasional	*Shub*
Silene pratensis (Rafn) Godr. & Gren.	White catchfly	disturbed areas	occasional	*Betz*
Stellaria graminea L.	Starwort	disturbed areas	rare	*Gibson*
Stellaria longifolia Muhl. ex Willd.	Long-leaved chickweed	sedge meadows	occasional	*4055*
Stellaria media (L.) Vill.	Common chickweed	disturbed areas, primarily in beech-maple forest, as along trails	occasional	*Assadi/Shub*
Celastraceae (Bittersweet Family)				
Celastrus orbiculata Thunb.	Oriental bittersweet	upland shrub thickets, edge of sedge meadows	occasional	*7085*
**Celastrus scandens L.*	American bittersweet	gravelly beech-maple forest (C2) above Cooper's Glen	rare	*Conde*
Euonymus alata (Thunb.) Sieb.	Winged wahoo	beech-maple forest	uncommon	*no collection*
Euonymus obovata Nutt.	Running strawberry bush	beech-maple forest and moist thickets	locally common	*Assadi*

Latin Name	Common Name	Habitat (Compartments)	Abundance	Collectors
Ceratophyllaceae (Hornwort Family)				
Ceratophyllum demersum L.	Coontail	Trout Run and Kalamazoo River	occasional	*no collection*
Chenopodiaceae (Goosefoot Family)				
Chenopodium album L.	Lamb's quarters	disturbed areas	occasional	*LaBatt*
Chenopodium glaucum L.	Oak-leaved goosefoot	old-field (O4)	rare	*no collection*
Chenopodium hybridum auct. non L.	Maple-leaved goosefoot	old-field (O4)	rare	*LaBatt*
****Cycloloma atriplicifolium (Spreng.) Coult.***	Winged pigweed	upland shrub thicket (U4)		*Conde*
Clusiaceae (St. John's-wort Family)				
Hypericum ascyron L.	Giant St. John's-wort	sedge meadow: East Fen (S1)	uncommon	*Broersma*
Hypericum boreale (Britt.) Bickn.	Northern St. John's-wort	sedge meadow (S2)	uncommon	*Conde*
Hypericum mutilum L.	Weak St. John's-wort	sedge meadow (S2)	uncommon	*7089*
Hypericum perforatum L.	Common St. John's-wort	disturbed areas; especially old-fields	occasional	*Assadi/Shub*
Hypericum punctatum Lam.	Spotted St. John's-wort	sedge meadows and moist areas in old-fields and forests	occasional	*Conde*
Commelinaceae (Spiderwort Family)				
Tradescantia ohiensis Raf.	Common spiderwort	upland shrub thicket (U4) in sandy soil	rare	*Lewis*
Convulvaceae (Morning-glory Family)				
****Convolvulus arvensis L.***	Field bindweed	railroad right-of-way		*Assadi/Shub*
Cornaceae (Dogwood Family)				
Cornus alternifolia L. f.	Alternate-leaved dogwood	beech-maple and floodplain forest, borders of shrub swamp	occasional	*Broersma*
Cornus amomum P. Mill.	Silky dogwood	sedge meadows, shrub swamp, and occasionally upland shrub thickets	occasional	*Betz*
Cornus florida L.	Flowering dogwood	beech-maple forest and adjacent old-fields, higher elevations in floodplain forest	occasional	*Walter*
Cornus foemina Mill. ssp. racemosa (Lam.) J.S. Wilson	Gray dogwood	beech-maple forest, sedge meadow, old-fields	abundant	*Shub*
Cornus stolonifera Michx.	Red-osier dogwood	sedge meadows, river and pond banks, shrub swamp, and occasionally upland shrub thickets	locally abundant	*Betz*
Crassulaceae (Stonecrop Family)				
Penthorum sedoides L.	Ditch stonecrop	depressions in Kalamazoo River floodplain (F1), shrub swamp (I3)	uncommon	*no collection*
Cucurbitaceae (Cucumber Family)				
Echinocystis lobata (Michx.) Torr. & Gray	Wild cucumber	edge of beech-maple forest: Cooper's Glen (C1) and Trout Run (F3)	uncommon	*Conde*
Cuscutaceae (Dodder Family)				
Cuscuta gronovii Willd. ex J.A. Schultes	Common dodder	sedge meadows	occasional	*Conde*

Cyperaceae (Sedge Family)				
Carex albursina Sheldon	Sedge	beech-maple and floodplain forests	occasional	*Conde*
Carex alopecoidea Tuckerman	Sedge	shrub swamp (I1)	uncommon	*3038*
Carex amphibola Steud.	Sedge	beech-maple and floodplain forests	occasional	*Conde*
Carex annectens (Bickn.) Bickn.	Sedge	border of esker (O3) and East Fen	rare	*3204*
Carex arctata Boott ex Hook.	Sedge	beech-maple forest and shrub swamp (I1)	occasional	*Conde*
Carex bebbii Olney ex Fern.	Sedge	sedge meadows throughout	common	*Conde*
Carex blanda Dewey	Sedge	beech-maple forest	occasional	*4119*
Carex bromoides Schkuhr ex Willd.	Sedge	floodplain forest, shrub swamp and borders of beech-maple forest	locally abundant	*Conde*
**Carex careyana Torr. ex Dewey*	Carey's sedge	Coopers Glen (C1)	uncommon	*no collection*
Carex cephaloidea (Dewey) Dewey	Sedge	beech-maple and floodplain forests	occasional	*3044*
Carex cephalophora Muhl. ex Willd.	Sedge	beech-maple forests, especially in sandy and rocky soils	occasional	*Conde*
Carex communis Bailey	Sedge	beech-maple and floodplain forests	common	*Conde*
Carex comosa Boott	Sedge	sedge meadow	occasional	*no collection*
Carex crinita Lam.	Sedge	Kalamazoo River floodplain and shrub swamp (I3)	occasional	*Conde*
Carex cristatella Britt.	Sedge	sedge meadow (E4)	uncommon	*Conde*
Carex frankii Kunth	Frank's sedge	wet woods (F4) near juncture of calcareous spring runs and South Stream	rare	*3293*
Carex gracillima Schwein.	Sedge	beech-maple and floodplain forests, upland shrub thickets	common	*Conde*
Carex granularis Muhl. ex Willd.	Sedge	sedge meadows and beech-maple forest (C3)	occasional	*Conde*
Carex grayi Carey	Sedge	Moist beech-maple forest and floodplain forest	occasional	*Conde*
Carex hirtifolia Mackenzie	Sedge	beech-maple and floodplain forests	common	*Conde*
Carex hitchcockiana Dewey	Sedge	beech-maple forest	occasional	*4106*
Carex hystericina Muhl. ex Willd.	Sedge	sedge meadows	occasional	*Conde*
Carex interior Bailey	Sedge	sedge meadows	uncommon	*3075*
Carex intumescens Rudge	Sedge	beech-maple forest and shrub swamp (I3)	uncommon	*Conde*
Carex jamesii Schwein.	James' sedge	beech-maple and floodplain forests	common	*Conde*
Carex lacustris Willd.	Sedge	sedge meadows and shrub-carr	locally abundant	*Conde*
Carex laevivaginata (Kükenth.) Mackenzie	Sedge	seep in Kalamazoo River floodplain (F2), sedge meadow (E2)	occasional	*Conde*
Carex lasiocarpa Ehrh. var. americana Fern.	Sedge	sedge meadows	uncommon	*3036*
Carex laxiflora Lam.	Sedge	beech-maple and floodplain forests	common	*Conde*
Carex leavenworthii Dewey	Leavenworth's sedge	esker through beech-maple forest (C4)	rare	*Hanes 3957*
Carex leptalea Wahlenb.	Sedge	sedge meadows	uncommon	*3054*
Carex leptonervia (Fern.) Fern.	Sedge	beech-maple forest and old-fields	common	*Conde*
Carex lupulina Muhl. ex Willd.	Sedge	wet depression in Kalamazoo River floodplain (F2)	rare	*Conde*
Carex lurida Wahlenb.	Sedge	sedge meadows	occasional	*Conde*
Carex muhlenbergii	Sedge	dry bank near Interpretive Center (C1)	rare	*4032*

Latin Name	Common Name	Habitat (Compartments)	Abundance	Collectors
Carex pedunculata Muhl. ex Willd.	Sedge	beech-maple forests	occasional	*3016*
Carex pellita Willd.	Sedge	sedge meadows	occasional	*3050, 4060*
Carex pensylvanica Lam.	Sedge	beech-maple forest and old-fields	common	*Conde*
Carex plantaginea Lam.	Sedge	beech-maple forest and old-fields	locally common	*Conde*
Carex prairea Dewey ex Wood	Sedge	sedge meadows	occasional	*3034*
Carex radiata (Wahlenb.) Small	Straight-styled wood sedge	higher elevation in Kalamazoo River floodplain (F2) and in Catalpa stand (U2)	uncommon	*3042*
Carex rosea Schkuhr ex Willd.	Curly-styled wood sedge	forests, old-fields, and upland shrub thickets	common	*Conde*
Carex scabrata Schwein.	Sedge	beech-maple forest: Cooper's Glen (C1)	uncommon	*4111*
Carex sparganioides Muhl. ex Willd.	Sedge	beech-maple forest and Catalpa stand (U2)	uncommon	*3047, Kenoyer 173*
Carex stipata Muhl. ex Willd.	Sedge	mostly wetter sedge meadows and shrub-carr	common	*Conde*
Carex stricta Lam.	Sedge	sedge meadows	abundant	*Conde*
Carex swanii (Fern.) Mackenzie	Sedge	forests, old-fields, and upland shrub thickets	occasional	*Conde*
Carex tenera Dewey	Sedge	sedge meadow (E5)	rare	*4114*
Carex tetanica Schkuhr	Sedge	marly seep in Source Marsh (E2) and Trout Run through Cooper's Glen (F3)	rare	*3079*
Carex tribuloides Wahlenb.	Sedge	ecotones of beech-maple forest, sedge meadow, and old-fields; shrub swamp (I3) and gravel pond (Pond 08)	locally common	*Conde*
Carex utriculata Boott	Sedge	wetter portions of sedge meadow	uncommon	*3080*
Carex vulpinoidea Michx.	Sedge	moist edge of beech-maple forest, sedge meadow, shrub swamp	common	*Conde*
Carex woodii Dewey	Sedge	Kalamazoo River floodplain (F1) and edges of sedge meadow	occasional	*3004*
**Cyperus filiculmis Vahl*	Slender cyperus	sandy hillside (U1)	rare	*Conde*
Cyperus rivularis Kunth	Shining cyperus	sandy edge of pond (Pond03)	rare	*Conde*
Cyperus strigosus L.	Long scaled nut sedge	marly pond edge (Pond 07) and sedge meadow: West Fen (S3)	uncommon	*Conde*
Eleocharis elliptica Kunth	Golden-seeded spike rush	sedge meadow: Source Marsh (E2)	uncommon	*4068*
Eleocharis erythropoda Steud.	Spike-rush	sedge meadows	occasional	*Conde*
Rhynchospora capillacea Torr.	Beak-rush	marly seep in Source Marsh (E2)	uncommon	*Conde*
Schoenoplectus acutus (Muhl. ex Bigelow) A.& D. Löve	Hardstem bulrush	sedge meadow	locally abundant	*Conde*
Schoenoplectus tabernaemontani (K.C. Gmel.) Palla	Softstem bulrush	sedge meadow	locally abundant	*Adams*
Scirpus atrovirens Willd.	Bulrush	sedge meadow	common	*Gibson*
Scirpus cyperinus (L.) Kunth	Wool-grass	sedge meadow and shrub swamp (I3)	occasional	*Conde*
Scirpus pendulus Muhl.	Pendulous bulrush	calcareous sand in upland shrub thicket (U4)	rare	*3126*

Dioscoreaceae (Wild Yam Family)				
Dioscorea villosa L.	Wild yam	beech-maple and floodplain forests	occasional	*Conde*
Dipsacaceae (Teasel Family)				
Dipsacus fullonum L.	Common teasel	disturbed forest and railroad margins	occasional	*Conde*
Elaeagnaceae (Oleaster Family)				
Elaeagnus umbellata Thunb.	Autumn olive	throughout in disturbed open areas and succesional forest	common	*Conde*
Ericaceae (Heath Family)				
Vaccinium corymbosum L.	Smooth highbush blueberry	shrub swamp in a "lobe" of Source Marsh (E2) and edge of dry knoll in Source Marsh	uncommon	*3077*
Euphorbiaceae (Spurge Family)				
Acalypha rhomboidea Raf.	Three-seeded mercury	disturbed sandy and gravelly soil	uncommon	*Conde*
Euphorbia maculata L.	Nodding spurge	disturbed sandy and gravelly soil	uncommon	*LaBatt*
Euphorbia nutans Lag.	Thyme-leaved spurge	margins of railroad	uncommon	*3297*
Euphorbia dentata Michx.	Toothed spurge	gravel pit (G)	uncommon	*4282*
Fabaceae (Bean Family)				
Amphicarpaea bracteata (L.) Fern.	Hog-peanut	beech-maple forest, shrub-carr, edges of sedge meadow	locally abundant	*Conde*
Apios americana Medik.	Groundnut	sedge meadow, shrub-carr, and swamp forest	occasional	*7032, 7094*
Cercis canadensis L.	Redbud	Kalamazoo River floodplain (F1)	uncommon	*Betz*
Coronilla varia L.	Crown-vetch	disturbed areas; especially roadsides	uncommon	*no collection*
Desmodium canadense (L.) DC.	Showy tick-trefoil	open habitats; old-fields and sedge meadow	occasional	*Conde*
Desmodium glutinosum (Muhl. ex Willd.) Wood	Clustered-leaved tick-trefoil	beech-maple and floodplain forest	occasional	*Conde*
Desmodium paniculatum (L.) DC.	Panicled tick-trefoil	openings in beech-maple forest and old-fields	occasional	*Conde*
Gleditsia triacanthos L.	Honey locust	Kalamazoo River floodplain (F2)	uncommon	*Conde*
Lathyrus palustris L.	Marsh pea	sedge meadows	occasional	*Conde*
Lotus corniculatus L.	Birdfoot trefoil	old-field (O9)	locally abundant	*7027*
Medicago lupulina L.	Black medick	old-fields and other disturbed areas; especially along trails	uncommon	*Assadi/Shub*
Medicago sativa L.	Alfalfa	old-fields and other disturbed areas; especially along trails	occasional	*Conde*
Melilotus alba Medikus	White sweet-clover	disturbed areas, especially in rocky soil	locally abundant	*Betz*
Melilotus officinalis (L.) Lam.	Yellow sweet-clover	disturbed areas, especially in rocky soil	common	*Assadi/Shub*
Robinia pseudoacacia L.	Black locust	old-fields and other disturbed areas; especially in sandy and rocky soil	locally common	*Conde*
Trifolium arvense L.	Rabbitfoot clover	old-fields	rare	*Betz*
Trifolium dubium Sibthorp	Little hop clover	old-fields and margins and hayfields	uncommon	*Betz*
Trifolium hybridum L.	Alsike clover	old-fields and margins and hayfields	uncommon	*Assadi/Shub*
Trifolium pratense L.	Red clover	old-fields and other disturbed areas	common	*Assadi/Shub*
Trifolium repens L.	White clover	old-fields and other disturbed areas; especially along trails	uncommon	*Assadi/Shub*
Vicia villosa Roth	Hariry vetch	old-fields	uncommon	*Conde*
Fagaceae (Beech Family)				
Fagus grandifolia Ehrh.	American beech	beech-maple and floodplain forests	occasional	*Walter*

Latin Name	Common Name	Habitat (Compartments)	Abundance	Collectors
Quercus alba L.	White oak	poplar planting (A1) and dry knoll in Source Marsh (E2)	occasional	*Conde*
Quercus bicolor Willd.	Swamp white oak	floodplain forest, shrub swamp and borders of beech-maple forest	occasional	*Conde*
Quercus macrocarpa Michx.	Bur oak	beech-maple forest, especially on gravelly ridge above Kalamazoo River	occasional	*Conde*
Quercus muehlenbergii Engelm.	Chinquapin oak	beech-maple forest and adjacent old-fields, especially in sandier soils	uncommon	*7036*
Quercus rubra L.	Red oak	beech-maple and floodplain forests	common	*Walter*
Quercus velutina Lam.	Black oak	sandy, successional beech-maple forest	occasional	*7038*
Fumariaceae (Fumitory Family)				
Dicentra canadensis (Goldie)	Squirrel corn	beech-maple forest	locally common	*Assadi/Shub*
Dicentra cucullaria (L.) Bernh.	Dutchman's breeches	beech-maple forest	locally common	*Betz*
Gentianaceae (Gentian Family)				
Gentiana andrewsii Griseb.	Bottle gentian	sedge meadows and adjacent moist old-field	occasional	*Walter*
Geraniaceae (Geranium Family)				
Geranium maculatum L.	Wild geranium	beech-maple and floodplain forests	common	*Betz*
Geranium robertianum L.	Herb robert	beech-maple forests and upland shrub thickets	occasional	*Assadi/Shub*
Grossulariaceae (Gooseberry Family)				
Ribes americanum P. Mill.	Wild black currant	sedge meadows, shrub-carr, and shrub swamps	occasional	*Conde*
Ribes cynosbati L.	Prickly Gooseberry	beech-maple and floodplain forests, adjacent disturbed ground	common	*Conde*
Ribes hirtellum Michx.	Swamp gooseberry	shrub swamp (I1)	uncommon	*Lewis*
Hamamelidaceae (Witch-hazel Family)				
Hamamelis virginiana L.	Witch-hazel	beech-maple and floodplain forests	occasional	*Conde*
Hydrocharitaceae (Frog's-bit Family)				
Elodea canadensis Michx.	Common waterweed	Kalamazoo River	uncommon	*Conde*
Hydrophyllaceae (Waterleaf Family)				
Hydrophyllum appendiculatum Michx	Great waterleaf	beech-maple and floodplain forests	locally common	*Assadi/Shub*
Hydrophyllum canadense L.	Canada waterleaf	Kalamazoo River floodplain (F1)	uncommon	*Shub*
Iridaceae (Iris Family)				
Iris pseudacorus L.	Water flag	Kalamazoo River floodplain (F1)		*Assadi/Shub*
Iris virginica L.	Southern blue flag	sedge meadows and floodplains	common	*Assadi/Shub*
Sisyrinchium angustifolium P. Mill.	Stout blue-eyed-grass	Kalamazoo River floodplain (F1) and edges of sedge meadow (S1)	uncommon	*Meininger*
Juglandaceae (Walnut Family)				
Carya cordiformis (Wangenh.) K. Koch	Bitternut hickory	beech-maple and floodplain forests and edges of shrub swamps	common	*Conde*

Carya ovata (P. Mill.) K. Koch	Shagbark hickory	beech-maple and floodplain forests	occasional	*7139*
Juglans cinerea L.	Butternut	beech-maple and floodplain forests	rare	*Starring*
Juglans nigra L.	Black walnut	throughout in all habitats	common	*Walter*
Juncaceae (Rush Family)				
Juncus brachycephalus (Engelm.) Buch.	Short-fruited rush	sedge meadows, marly gravel pond (Pond06)	occasional	*Conde*
Juncus canadensis J. Gay ex Laharpe	Canadian rush	marly gravel pond (Pond06)	uncommon	*Conde*
Juncus dudleyi Wieg.	Dudley's rush	sedge meadow, old-fields, sandy pond edge: Source Pond (Pond09)	occasional	*Conde*
Juncus effusus L.	Soft-stemmed rush	sedge meadows, gravel pond (Pond08)	occasional	*Conde*
Juncus tenuis Willd.	Path rush	beech-maple forest, old-fields, upland shrub thickets	locally common	*Conde*
Luzula acuminata Raf.	Hairy wood rush	beech-maple forest	occasional	*Conde*
Luzula multiflora (Ehrh.) Lej.	Common wood rush	beech-maple forest	occasional	*Conde*
Lamiaceae (Mint Family)				
Blephilia hirsuta (Pursh) Benth.	Wood mint	beech-maple and floodplain forests, especially on rocky soil	uncommon	*Betz*
Clinopodium vulgare L.	Wild basil	forest margins and old-fields	occasional	*Assadi/Shub*
Collinsonia canadensis L.	Richweed	springy ground in wet forests	uncommon	*7141*
Glechoma hederacea L.	Ground ivy	hayfield (H3)	uncommon	*no collection*
****Lamium maculatum L.***	Spotted dead nettle	disturbed areas		*Assadi/Shub*
Lamium purpureum L.	Purple dead-nettle	disturbed areas	occasional	*Assadi/Shub*
Leonurus cardiaca L.	Motherwort	disturbed areas	occasional	*Betz*
Lycopus americanus Muhl. ex W. Bart.	Common water horehound	sedge meadows and shrub-carr	common	*Conde*
Lycopus uniflorus Michx.	Northern bugle weed	sedge meadows and shrub swamps	occasional	*Conde*
Mentha x piperita L. (pro sp.) [aquatica x spicata]	Peppermint	near springs in sedge meadows	locally common	*7088*
Mentha arvensis L.	Wild mint	sedge meadows and shrub-carr	occasional	*Conde*
Mentha spicata L.	Spearmint	moist ground near streams and sedge meadows	uncommon	*Conde*
Monarda fistulosa L.	Wild bergamot	sedge meadows, forest openings, old-fields, upland shrub thickets	common	*Assadi/Shub*
Monarda punctata L.	Horsemint	disturbed sandy soil (U4)	rare	*Photo*
Nepeta cataria L.	Catnip	disturbed areas	uncommon	*Assadi/Shub*
Origanum vulgare L.	Wild marjoram	disturbed areas, especially along trails and roadsides	uncommon	*7090*
Physostegia virginiana (L.) Benth.	False dragonhead	Kalamazoo River floodplain, in a moist depression and shaded edge of sedge meadow	uncommon	*7119*
Prunella vulgaris L.	Lawn prunella	throughout in all habitats	occasional	*Assadi/Shub*
Scutellaria galericulata L.	Common skullcap	shrub-carr	uncommon	*no collection*
Scutellaria lateriflora L.	Mad-dog skullcap	sedge meadow, shrub-carr, and swamp forest	occasional	*Conde*
Stachys palustris L.	Woundwort	shrub-carr and sedge meadow along Kalamazoo River	uncommon	*3180*
Stachys tenuifolia Willd.	Smooth hedge nettle	shrub-carr and sedge meadow along Kalamazoo River	rare	*4264, 4279*
Teucrium canadense L.	Wood sage	Kalamazoo River floodplain (F2)	rare	*3235*

Latin Name	Common Name	Habitat (Compartments)	Abundance	Collectors
Lauraceae (Laurel Family)				
Lindera benzoin (L.) Blume	Spicebush	beech-maple and floodplain forests, shrub swamps	abundant	*Chape*
Sassafras albidum (Nutt.) Nees	Sassafras	beech-maple and floodplain forests, old-fields	occasional	*Chape*
Lemnaceae (Duckweed Family)				
Lemna minor L.	Small duckweed	ponds	locally common	*no collection*
Wolffia columbiana Karst.	Common water meal	ponds	uncommon	*no collection*
Liliaceae (Lily Family)				
Allium canadense L.	Wild garlic	moist beech-maple forest, floodplain forests	occasional	*Assadi/Shub*
Allium tricoccum Ait.	Wild leek	beech-maple and floodplain forests	common	*Conde*
Allium vineale L.	Field garlic	disturbed ground, especially old-fields and near trails	occasional	*Gibson*
Convallaria majalis L.	Lily-of-the-valley	disturbed successional forest (U7)	uncommon	*no collection*
Erythronium americanum Ker-Gawl.	Yellow trout lily	beech-maple and floodplain forests and adjacent old-fields	common	*Norris*
Hemerocallis fulva (L.) L.	Orange day-lily	disturbed ground, especially near roads and old homesites	occasional	*Assadi/Shub*
Lilium michiganense Farw.	Michigan lily	sedge meadows	occasional	*Assadi/Shub*
Maianthemum canadense Desf.	Canada mayflower	beech-maple and floodplain forests, shrub swamps	common	*Assadi/Shub*
Narcissus pseudonarcissus L.	Daffodil	Kalamazoo River floodplain (F1)	rare	*no collection*
Polygonatum pubescens (Willd.) Pursh	Downy Solomon seal	beech-maple and floodplain forests	occasional	*Norris*
Smilacina racemosa (L.) Desf.	False spikenard	beech-maple and floodplain forests	occasional	*Betz*
Smilacina stellata (L.) Desf.	Starry false Solomon-seal	beech-maple forests and sedge meadows	uncommon	*Betz*
Smilax lasioneura Hook.	Carrion-flower	beech-maple forests and upland shrub thickets	occasional	*Assadi/Shub*
Smilax tamnoides L.	Bristly green-brier	beech-maple and floodplain forests, old-fields	occasional	*Conde*
**Trillium cernuum L.*	Nodding trillium	beech-maple forest	rare	*Weston/ Kummer*
Trillium grandiflorum (Michx.) Salisb.	Common trillium	beech-maple and floodplain forests	locally common	*Betz*
Uvularia grandiflora Sm.	Bellwort	beech-maple forests	occasional	*Betz*
Limnanthaceae (False Mermaid Family)				
Floerkea proserpinacoides Willd.	False mermaid	beech-maple and floodplain forests	locally abundant	*Conde*
Lythraceae (Loosestrife Family)				
Decodon verticillatus (L.) Ell.	Swamp loosestrife	wetter portions of sedge meadow	occasional	*no collection*
Lythrum salicaria L.	Purple loosestrife	sedge meadows	occasional	*Conde*
Magnoliaceae (Magnolia Family)				
Liriodendron tulipifera L.	Tulip tree	beech-maple and floodplain forests	occasional	*Walter*
Malvaceae (Mallow Family)				
Abutilon theophrasti Medik.	Velvetleaf	old-fields and farm field margins	uncommon	*Assadi/Shub*
Menispermaceae (Moonseed Family)				
Menispermum canadense L.	Moonseed	beech-maple and floodplain forests, shrub-carr	occasional	*Broersma*

Molluginaceae (Carpet Weed Family)				
Mollugo verticillata L.	Carpet weed		rare	*LaBatt*
Monotropaceae (Indian-pipe Family)				
Monotropa uniflora L.	Indian pipe	beech-maple forests: Pioneer Woods (C4)	uncommon	*Broersma*
Moraceae (Mulberry Family)				
Maclura pomifera (Raf.) Schneid.	Osage orange	roadside (old farm lane) along hayfield (H1)	uncommon	*Conde*
Morus alba L.	White mulberry	throughout in all habitats	common	*Conde*
Nyctaginaceae (Four-o'clock Family)				
Mirabilis nyctaginea (Michx.) MacM.	Four-o'clock	railroad right-of-way	uncommon	*Assadi/Shub*
Nyssaceae (Tupelo Family)				
Nyssa sylvatica Marsh.	Black gum	edge of shrub swamp (I3)	rare	*4076*
Oleaceae (Olive Family)				
Fraxinus americana L.	White ash	beech-maple and floodplain forests, adjacent old-fields	common	*Conde*
Fraxinus nigra Marsh.	Black ash	floodplain forests and border of sedge meadow	locally common	*7035*
Fraxinus pennsylvanica Marsh.	Red ash	beech-maple and floodplain forests, adjacent old-fields	occasional	*7041*
Fraxinus quadrangulata Michx.	Blue ash	gravel ridges above Cooper's Glen (C2) and Kalamazoo River	uncommon	*Lewis*
Ligustrum vulgare L.	Common privet	disturbed margins of beech-maple forest, gravel pit (G), levy in floodplain of Kalamazoo River (F2)	occasional	*7120*
Syringa vulgaris L.	Common lilac	margin of beech-maple forest: Pioneer Woods (C4)	uncommon	*no collection*
Onagraceae (Evening-primrose Family)				
Circaea lutetiana L.	Enchanter's-nightshade	forested habitat of all kinds	common	*Betz*
Epilobium coloratum Biehler	Cinnamon willow-herb	moist and wet ground generally	occasional	*Conde*
Epilobium hirsutum L.	Great hairy willow-herb	along Trout Run in sedge meadow: West Fen (S3)	locally common	*Conde*
Epilobium leptophyllum Raf.	Fen willow-herb	sedge meadow: Source Marsh (E2)	uncommon	*7093*
Ludwigia palustris (L.) Ell.	Water purslane	inundated muck in springy sedge meadow	locally common	*4361*
Oenothera biennis L.	Common evening-primrose	old-fields and forest margins	occasional	*Assadi/Shub*
Oenothera laciniata Hill	Ragged evening-primrose	old-field (O4)	rare	*no collection*
Orchidaceae (Orchid Family)				
**Aplectrum hyemale (Muhl. ex Willd.) Torr.*	Adam and Eve	beech-maple forest: Pioneer Woods (C4)	rare	*Conde*
Cypripedium parviflorum Salisbury var. makasin (Farwell) Sheviak	Yellow lady-slipper	sedge meadow along Kalamazoo River (F1)	rare	*7136*
Cypripedium reginae Walt.	Showy lady-slipper	one small population in narrow sedge meadow	rare	*Photo*
Epipactis helleborine (L.) Crantz	Helleborine	gravel ridges above Cooper's Glen (C2) and Kalamazoo River	uncommon	*Photo*
Liparis liliifolia (L.) L.C. Rich. ex Ker-Gawl.	Lily-leaved twayblade	sandy, successional beech-maple forest edges	rare	*Photo*
Platanthera lacera (Michaux) G. Don	Ragged fringed orchid	on esker (O3) adjacent to East Fen; after clearing in 2008	rare	*Photo*
Spiranthes cernua (L.) L.C. Rich.	Nodding ladies'-tresses	sedge meadows throughout	occasional	*Conde*

Latin Name	Common Name	Habitat (Compartments)	Abundance	Collectors
Orobanchaceae (Broom-rape Family)				
Conopholis americana (L.) Wallr. f.	Squawroot	floodplain forest (F2)	uncommon	*Assadi/Shub*
Epifagus virginiana (L.) W. Bart.	Beech drops	beech-maple forests throughout	occasional	*Adams*
Oxalidaceae (Wood-sorrel Family)				
Oxalis stricta L.	Common yellow wood-sorrel	along trails and other disturbed areas	occasional	*Assadi/Shub*
Papaveraceae (Poppy Family)				
Chelidonium majus L.	Celandine	disturbed margins of beech-maple forest near railroad	uncommon	*no collection*
Sanguinaria canadensis L.	Bloodroot	beech-maple forest throughout	occasional	*Assadi/Shub*
Stylophorum diphyllum (Michx.) Nutt.	Wood poppy	In beech-maple forest near Cooper's Glen (C1)	locally common	*Betz*
Phytolaccaceae (Pokeweed Family)				
Phytolacca americana L.	Pokeweed	disturbed areas throughout	occasional	*LaBatt*
Plantaginaceae (Plantain Family)				
****Plantago aristata Michx.***	Bracted plantain			*LaBatt*
Plantago lanceolata L.	English plantain	disturbed areas throughout	occasional	*Assadi/Shub*
Plantago rugelii Dcne.	Red-stalked plantain	throughout in all upland habitats	occasional	*Shub*
Platanaceae (Sycamore Family)				
Platanus occidentalis L.	Sycamore	Kalamazoo River floodplain and adjacent beech-maple forest	occasional	*Conde*
Poaceae (Grass Family)				
Agropyron repens (L.) Beauv.	Quack grass	hayfields and old-fields	occasional	*Conde*
Agropyron trachycaulum (Link) Malte ex H.F. Lewis	Slender wheat grass	old poplar plantation (A3), and sedge meadow: Source Marsh (E2)	uncommon	*4135*
Agrostis gigantea Roth.	Redtop	local seepage in gravel pit (G) and sedge meadow (S2)	occasional	*Conde*
Agrostis hyemalis (Walt.) B.S.P.	Ticklegrass	beech-maple forest: Pioneer Woods (C4) and border of shrub swamp (I3)	occasional	*3336*
Agrostis stolonifera L.	Creeping bent	large mat in loose muck along Trout Run through Cooper's Glen (F3)	common	*Conde*
Andropogon virginicus L.	Broom-sedge	on esker along East Fen (O3)	common	*Conde*
Aristida purpurascens Poir.	Three-awned grass	old sand mine (U4)	occasional	*3343*
Arrhenatherum elatius (L.) Beauv. ex J. & K. Presl	Tall oatgrass	gravel pit (G) and old-fields	occasional	*Conde*
Brachyelytrum erectum (Schreb. ex Spreng.) Beauv.	Long-awned wood grass	Kalamazoo River floodplain and shrub swamp (I2)	occasional	*Conde*
Bromus ciliatus L.	Fringed brome	sedge meadow throughout	occasional	*Conde*
Bromus commutatus Schrad.	Hairy chess	hayfields and old-fields	uncommon	*4074*
Bromus inermis Leyss.	Smooth brome	disturbed areas, especially ofld hayfields and old-fields	common	*Broersma*
Bromus latiglumis (Shear) A.S. Hitchc.	Ear-leaved brome	beech-maple forest: South Property (C3) and floodplain forest (F2)	uncommon	*3197*
Bromus mollis auct. non L.	Soft chess	gravel pit (G)	occasional	*3045*
Bromus pubescens Muhl. ex Willd.	Canada brome	beech-maple and floodplain forest	occasional	*Conde*

***Bromus racemosus* L.**	Smooth chess	old sand mine (U4)	uncommon	*LaBatt*
****Bromus squarrosus* L.**	Brome		uncommon	*Betz*
***Bromus tectorum* L.**	Cheat grass	old sand mine (U4)	uncommon	*Conde*
Calamagrostis canadensis (Michx.) Beauv.	Blue-joint grass	sedge meadow throughout	occasional	*Conde*
**Cenchrus longispinus (Hack.) Fern.*	Long-spined sandbur	disturbed ground	uncommon	*LaBatt*
Cinna arundinacea L.	Wood rcedgrass	beech-maple and floodplain forest, shrub swamp	occasional	*Conde*
***Dactylis glomerata* L.**	Orchard grass	disturbed areas, especially ofld hayfields and old-fields	occasional	*LaBatt*
Danthonia spicata (L.) Beauv. ex Roemer & J.A. Schultes	Poverty grass	beech-maple forest and old-fields	occasional	*Conde*
***Digitaria sanguinalis* (L.) Scop.**	Hairy crab grass	edge of tilled field (T1)	occasional	*LaBatt*
****Echinochloa crus-galli* (L.) Beauv.**	Barnyard grass	old-field (O4)		*Conde*
Echinochloa muricata (Beauv.) Fern.	Barnyard grass	old-field (O4)	uncommon	*Conde*
Elymus riparius Wieg.	Riverbank wild-rye	floodplain forest and sedge meadow	occasional	*Conde*
Elymus villosus Muhl. ex Willd.	Silky wild-rye	Kalamazoo River floodplain (F2)	occasional	*Conde*
Elymus virginicus L.	Virginia wild-rye	floodplain forest and sedge meadow	occasional	*3236*
***Eragrostis cilianensis* (All.) Vign. ex Janchen**	Stink grass	old-fields	uncommon	*Conde*
Eragrostis hypnoides (Lam.) B.S.P.	Creeping love grass	shallow water in gravel pond (Pond 05)	locally abundant	*3281*
Eragrostis pectinacea (Michx.) Nees ex Steud.	Love grass	edge of tilled field (T1)	occasional	*Conde*
Eragrostis spectabilis (Pursh) Steud.	Purple love grass	openings in sandy beech-maple forest and old-fields	common	*Conde*
***Festuca arundinacea* Schreb.**	Tall fescue	along trails and other disturbed areas	occasional	*Conde*
***Festuca rubra* L.**	Red fescue	along trails and other disturbed areas	occasional	*Conde*
Festuca subverticillata (Pers.) Alexeev	Nodding fescue	beech-maple and floodplain forest, shrub swamp	occasional	*Conde*
Glyceria septentrionalis A.S. Hitchc.	Floating manna grass	edge of gravel pond (Pond 08)	locally common	*4359*
Glyceria striata (Lam.) A.S. Hitchc.	Fowl manna grass	moist beech-maple and floodplain forest, shrub swamps and sedge meadow	occasional	*Conde*
Hystrix patula Moench	Bottlebrush grass	forested habitat of all kinds	occasional	*Betz*
Leersia oryzoides (L.) Sw.	Cut grass	wet ground of all kinds	locally abundant	*Conde*
Leersia virginica Willd.	White grass	moist beech-maple and floodplain forest	occasional	*Conde*
Leptoloma cognatum (J.A. Schultes) Chase	Fall witch grass	on esker along East Fen (O3), and sandy old-field above gravel pit (O6)	occasional	*Conde*
Milium effusum L.	Wood millet	beech-maple and floodplain forest	uncommon	*Conde*
Muhlenbergia frondosa (Poir.) Fern.	Common satin grass	disturbed ground as along trails; also in sedge meadow (E3)	occasional	*3298*
Muhlenbergia glomerata (Willd.) Trin.	Marsh wild-timothy	sedge meadow throughout	occasional	*Conde*
Muhlenbergia mexicana (L.) Trin.	Leafy satin grass	sedge meadow throughout	occasional	*Conde*
Muhlenbergia schreberi J.F. Gmel.	Nimblewill	disturbed ground as along trails and edges of hayfields	uncommon	*Conde*
Muhlenbergia sylvatica Torr. ex Gray	Woodland satin grass	beech-maple forest: Cooper's Glen (C1)	occasional	*3291*
**Panicum capillare L.*	Old witch grass	upland shrub thicket (U1)	uncommon	*LaBatt*
Panicum clandestinum L.	Panic grass	Kalamazoo River floodplain (F1) and adjacent railroad margin	occasional	*Conde*

Latin Name	Common Name	Habitat (Compartments)	Abundance	Collectors
Panicum dichotomiflorum Michx.	Panic grass	old-fields	uncommon	*Conde*
Panicum implicatum Scribn.	Panic grass	gravelly soil in beech-maple forest, as along esker (C4, O3); also in sedge meadow: Source Marsh (E2)	common	*4351*
Panicum miliaceum L.	Broomcorn millet	old-field (O4)	occasional	*4215*
Panicum oligosanthes J.A. Schultes	Panic grass	old sand mine (U4) and sandy opening in beech-maple forest (C5)	uncommon	*3083, 4300*
Panicum praecocius A.S. Hitchc. & Chase	Early-branching panic-grass	old-fields, and sandy opening in beech-maple forest, including dry knoll in Source Marsh (E2)	uncommon	*Conde*
Panicum rigidulum Bosc ex Nees	Panic grass	margin of hayfield (H2)	uncommon	*no collection*
Phalaris arundinacea L.	Reed canary grass	disturbed open wetlands and adjacent uplands	occasional	*Conde*
Phleum pratense L.	Timothy	hayfields and old-fields	common	*Broersma*
Poa alsodes Gray	Bluegrass	moist bottom in Kalamazoo River floodplain (F1)	occasional	*4098*
Poa annua L.	Annual bluegrass	along trails and other disturbed areas	uncommon	*Conde*
Poa compressa L.	Canada bluegrass	sandy and gravelly ground in thin beech-maple forest	occasional	*Conde*
Poa pratensis L.	Kentucky bluegrass	disturbed uplands and sedge meadow	occasional	*Assadi/Shub*
Poa sylvestris Gray	Woodland bluegrass	beech-maple forest: Cooper's Glen (C1)	uncommon	*4104*
Poa trivialis L.	Bluegrass	beech-maple forest: South Property (C3)	uncommon	*Conde*
Setaria faberi Herrm.	Giant foxtail	edge of tilled field (T1)	occasional	*Conde*
****Setaria glauca (L.) Beauv.***	Yellow foxtail	old-field (O9)	occasional	*Conde*
Setaria viridis (L.) Beauv.	Green foxtail	old-fields and edge of hayfields	occasional	*Conde*
Sphenopholis intermedia (Rydb.) Rydb.	Slender wedgegrass	moist bottom in Kalamazoo River floodplain (F1)	occasional	*4099*
Tridens flavus (L.) A.S. Hitchc.	Purpletop	disturbed ground on edge of forested areas	occasional	*Conde*
Polemoniaceae (Phlox Family)				
Phlox divaricata L.	Woodland phlox	beech-maple and floodplain forest	occasional	*Betz*
Polygonaceae (Smartweed Family)				
Polygonum amphibium L.	Water smartweed	shallow water in sedge meadows	occasional	*4286*
Polygonum arifolium L.	Tear-thumb	shrub-carr (E2) and shrub swamp (I3)	locally common	*Conde*
Polygonum aviculare L.	Knot-grass	disturbed upland shrub thicket	uncommon	*Conde*
Polygonum convolvulus L.	False buckwheat	old-field (O4)	common	*LaBatt*
Polygonum cuspidatum Sieb. & Zucc.	Japanese knotweed	margin of farm field (T1)	uncommon	*Walter*
**Polygonum pensylvanicum L.*	Pennsylvania smartweed	moist, disturbed areas	uncommon	*Conde*
Polygonum persicaria L.	Lady's thumb	sedge meadows	occasional	*Betz*
Polygonum punctatum Ell.	Smartweed	sedge meadow and shrub swamp	occasional	*Conde*
Polygonum sagittatum L.	Arrow-leaved tear-thumb	sedge meadow and shrub swamp	occasional	*Conde*
Polygonum virginianum L.	Jumpseed	Forested habitat of all kinds	occasional	*Conde*
Rumex acetosella L.	Sheep sorrel	old-fields and other disturbed areas	occasional	*Betz*
Rumex crispus L.	Curly dock	Disturbed areas	occasional	*Assadi/Shub*

***Rumex obtusifolius* L.**	Bitter dock	Disturbed areas, especially along trails through moist beech-maple forest and mucky soil	occasional	*Assadi/Shub*
Rumex orbiculatus Gray	Great water dock	sedge meadows	uncommon	*Broersma*
Rumex verticillatus L.	Water dock	sedge meadows	uncommon	*LaBatt*
Portulaceae (Purslane Family)				
Claytonia virginica L.	Spring-beauty	beech-maple and floodplain forest; occasional adjacent old-field or shrub thicket	abundant	*Betz*
Potamogetonaceae (Pondweed Family)				
***Potamogeton crispus* L.**	Pondweed	artificial pond in Trout Run (Pond 02)	locally common	*Conde*
Primulaceae (Primrose Family)				
Lysimachia ciliata L.	Fringed loosestrife	moist bottom in Kalamazoo River floodplain, shrub-carr throughout	occasional	*Conde*
***Lysimachia nummularia* L.**	Creeping Jenny)	Kalamazoo River floodplain	common	*Conde*
Lysimachia quadriflora Sims	Whorled Loosestrife	calcareous seep in sedge meadow: Source Marsh (E2)	uncommon	*7082*
Lysimachia thyrsiflora L.	Tufted loosestrife	sedge meadows throughout	occasional	*Assadi/Shub*
Samolus parviflorus Raf.	Water-pimpernel	exposed mudflat in Kalamazoo River floodplain (F2)	uncommon	*4281*
Pyrolaceae (Shinleaf Family)				
Chimaphila maculata (L.) Pursh	Spotted wintergreen	sandy/gravelly soil on esker	uncommon	*7037*
Pyrola elliptica Nutt.	Large-leaved shinleaf	ecotone between beech-maple forest and sedge meadow	uncommon	*Gibson*
Ranunculaceae (Buttercup Family)				
Actaea pachypoda Ell.	Doll's-eyes	beech-maple and floodplain forest	occasional	*Betz*
Anemone quinquefolia L.	Wood anemone	beech-maple and floodplain forest; occasional wet depression contained within	common	*Betz*
Anemone virginiana L.	Thimbleweed	young forests and old-fields	occasional	*Kelley*
Anemonella thalictroides (L.) Spach	Rue anemone	beech-maple and floodplain forest; especially in sandier soil of esker	occasional	*7033*
Aquilegia canadensis L.	Wild columbine	low terraces in Kalamazoo River floodplain (F2)	uncommon	*Assadi/Shub*
Caltha palustris L.	Marsh-marigold	C1/3, E2-3, F1-2/4, I1, S1-2	common	*Betz*
***Cimicifuga racemosa* (L.) Nutt.**	Black snakeroot	disturbed beech-maple forest: South Property (C3)	rare	*no collection*
Clematis virginiana L.	Virgin's bower	shrub-carr and shrub swamp (I1)	occasional	*Conde*
Hepatica acutiloba DC.	Sharp-lobed hapatica	beech-maple and floodplain forest	occasional	*Assadi/Shub*
Hepatica americana (DC.) Ker-Gawl.	Round-lobed hepatica	beech-maple (C4) and floodplain forest (F1)	uncommon	*Conde*
Isopyrum biternatum (Raf.) Torr. & Gray	False rue anemone	beech-maple and floodplain forest	common	*Assadi/Shub*
Ranunculus abortivus L.	Small-flowered buttercup	beech-maple and floodplain forest, shrub swamp and moist old-fields	uncommon	*Assadi/Shub*
Ranunculus hispidus Michx.	Swamp buttercup	floodplain forest and shrub swamp; moist margins of beech-maple forest	common	*Betz*
Ranunculus pensylvanicus L. f.	Bristly crowfoot	marly gravel pond (Pond06)	uncommon	*4288*

Latin Name	Common Name	Habitat (Compartments)	Abundance	Collectors
Ranunculus recurvatus Poir.	Hooked crowfoot	throughout in both disturbed and mature forested habitats; some adjacent old-fields	occasional	*Conde*
Ranunculus sceleratus L.	Cursed crowfoot	shallow water in shrub swamp (I4) and sedge meadow (S2); also in ponds (Pond 08 and 09)	uncommon	*4110*
Thalictrum dasycarpum Fisch. & Avé-Lall.	Purple meadow-rue	sedge meadow and thickets in the Kalamazoo River floodplain	occasional	*Assadi/Shub*
Thalictrum dioicum L.	Early meadow-rue	floodplain forest and adjacent railroad margin	uncommon	*Betz*
Rhamnaceae (Buckthorn Family)				
Rhamnus alnifolia L'Hér.	Alder-leaved buckthorn	sedge meadows: Source Marsh (E1-2) and Kalamazoo River floodplain (F1)	locally common	*Betz*
Rhamnus cathartica L.	Common buckthorn	beech-maple and floodplain forest, pine and aspen plantations, some old-fields and upland shrub thickets	locally common	*Conde*
Rhamnus frangula L.	Glossy buckthorn	sedge meadow and other wet areas; adjacent uplands	locally common	*Conde*
Rosaceae (Rose Family)				
Agrimonia gryposepala Wallr.	Tall agrimony	beech-maple and floodplain forest, edge of shrub-carr	common	*Adams*
Agrimonia pubescens Wallr.	Soft agrimony	somewhat sandier beech-maple and floodplain forest	uncommon	*7121*
Amelanchier laevis Wieg.	Smooth shadbush	beech-maple forest, pioneering in gravel pit (G)	uncommon	*3006*
Aronia prunifolia (Marsh.) Rehd.	Black chokeberry	sedge meadow and shrub-carr: Source Marsh (E1,2)	uncommon	*7031*
**Crataegus chrysocarpa Ashe*	Golden fruited thorn	shrub thicket (U1)	uncommon	*Conde*
**Crataegus flabellata (Spach) Kirchn.*	Variable thorn	beech-maple forest: Pioneer Woods (C4)	uncommon	*Conde*
**Crataegus mollis Scheele*	Red fruited thorn	Kalamazoo River floodplain (F1)	uncommon	*Conde*
Crataegus punctata Jacq.	Dotted hawthorn	beech-maple forest: Cooper's Glen (C1) and shrub thicket on old sand mine (U4)	uncommon	*Conde*
Fragaria virginiana Duchesne	Wild strawberry	open habitats of all kinds, old-fields, poplar stands; also edges of forest and along trails	common	*Betz*
Geum aleppicum Jacq.	Yellow avens	beech-maple and floodplain forest, adjacent moist old-fields	occasional	*Gibson*
Geum canadense Jacq.	White avens	forested habitat of all kinds and adjacent old-fields and shrub thickets	common	*Betz*
Geum rivale L.	Purple avens	sedge meadows	uncommon	*Conde*
****Malus baccata (L.) Borkh.***	Siberian crabapple	beech-maple forest: Cooper's Glen (C1)	uncommon	*Conde*
Malus coronaria (L.) P. Mill.	American crab	poplar stand (A3) and edge of beech-maple forest: Cooper's Glen (C1)	uncommon	*Assadi/Shub*
Malus prunifolia (Willd.) Borkh.	Chinese apple	early-successional forest	uncommon	*Conde*
Malus pumila P. Mill.	Apple	old-fields, poplar stands, early-successional forests	uncommon	*7142*
****Potentilla argentea L.***	Silvery cinquefoil	old-fields and other disturbed places	uncommon	*Assadi/Shub*
Potentilla fruticosa auct. non L.	Shrubby cinquefoil	sedge meadow: West Fen (S3)	rare	*3317*
Potentilla recta L.	Rough-fruited cinquefoil	old-fields and other disturbed places	occasional	*Betz*

Potentilla simplex Michx.	Common cinquefoil	old-fields and other disturbed places	uncommon	*Assadi/Shub*
Prunus avium (L.) L.	Sweet cherry	early-successional forest and edges, shrub thickets, gravel pit (G)	occasional	*Conde*
****Prunus mahaleb L.***	Mahaleb cherry		uncommon	*Betz*
Prunus serotina Ehrh.	Wild black cherry	throughout in both disturbed and mature forested habitats; some adjacent old-fields	abundant	*Conde*
Prunus virginiana L.	Choke cherry	beech-maple and floodplain forest and some adjacent old-fields; also in shrub swamp (I2)	occasional	*Betz*
Pyrus communis L.	Pear	poplar stand (A1)	uncommon	*Conde*
Rosa cinnamomea L.	Cinnamon rose	shrub thicket (U5) and along edge of gravel pit and South Property	rare	*7124*
Rosa multiflora Thunb. ex Murr.	Multiflora rose	throughout in both disturbed and mature forested habitats, adjacent old-fields, sedge meadows and shrub-carr	abundant	*Conde*
Rosa palustris Marsh.	Swamp rose	wet ground of all kinds, especially shrub-carr	common	*Conde*
Rubus allegheniensis Porter	Common blackberry	old-fields, hayfields, and shrub thickets; margins of forest, shrub swamps	common	*Betz*
Rubus flagellaris Willd.	Northern dewberry	sandy/gravelly soil on esker	occasional	*7084*
Rubus hispidus L.	Swamp dewberry	shrub-carr and shrub swamp	uncommon	*no collection*
Rubus occidentalis L.	Black raspberry	throughout in most disturbed or successional habitats	occasional	*Broersma*
Rubus pensilvanicus Poir.	Dewberry	old-fields and opening in beech-maple forest: Cooper's Glen (C1)	uncommon	*Broersma*
Rubus pubescens Raf.	Dwarf raspberry	beech-maple and floodplain florest	uncommon	*4024*
Rubus setosus Bigelow	Bristly blackberry	beech-maple and floodplain florest, adjacent old-field	occasional	*4051*
Rubus strigosus Michx.	Wild red raspberry	edge of beech-maple forest and sedge meadow, moist old-fields	occasional	*7087*
Sorbus decora (Sarg.) Schneid.	Mountain-ash	gravelly beech-maple forest (C4) along esker	rare	*Conde*
Spiraea alba Du Roi	Meadowsweet	shrub swamp (I3)	uncommon	*no collection*
Rubiaceae (Bedstraw Family)				
Cephalanthus occidentalis L.	Buttonbush	shrub swamp and wetter depressions in sedge meadow	uncommon	*Conde*
Galium aparine L.	Annual bedstraw	beech-maple and floodplain forest (especially in areas of bare soil), shrub thickets and shrub -carr	common	*Betz*
Galium asprellum Michx.	Rough bedstraw	sedge meadow	occasional	*Conde*
Galium circaezans Michx.	White wild licorice	beech-maple and floodplain forest	occasional	*Broersma*
Galium concinnum Torr. & Gray	Shining bedstraw	first bottom along Kalamazoo River floodplain (F1)	uncommon	*3099*
**Galium lanceolatum Torr.*	Wild licorice	beech-maple forest: Pioneer Woods (C4)	uncommon	*Conde*
Galium mollugo L.	White bedstraw	hayfield (H3)	uncommon	*no collection*
Galium obtusum Bigelow	Wild madder	sedge meadow (S2)	uncommon	*4143*
Galium trifidum L.	Small bedstraw	sedge meadow: Source Marsh (E1,2)	uncommon	*4137*

Latin Name	Common Name	Habitat (Compartments)	Abundance	Collectors
Galium triflorum Michx.	Fragrant bedstraw	beech-maple and floodplain forest	occasional	*Prentice*
Mitchella repens L.	Partridge berry	sandy border of esker with Cooper's Glen (O3) and adjacent rise in Trout Run floodplain (F3); oak knoll in Source Marsh (E2)	uncommon	*Conde*
Rutaceae (Citrus Family)				
**Ptelea trifoliata* L.	Common hoptree	Coopers Glen (C1)	rare	*Conde*
Zanthoxylum americanum P. Mill.	Prickly-ash	borders of beech-maple and floodplain forest, shrub thickets and shrub swamp, hill above gravel pit (G)	occasional	*Walter*
Salicaceae (Willow Family)				
Populus deltoides Bartr. ex Marsh.	Cottonwood	various habitats: Kalamazoo River floodplain (F2), gravel pit (G), old-field (O5), sedge meadow: West Fen (S3), shrub thicket (U4)	occasional	*Walter*
Populus grandidentata Michx.	Big-toothed aspen	sandier ground on edge of forests (C3, F2) and shrub thickets (U2,4)	locally common	*Conde*
Populus tremuloides Michx.	Quaking aspen	beech-maple forest, edge of sedge meadow, and some adjacent old-fields	uncommon	*Betz*
Salix amygdaloides Anderss.	Peach-leaved willow	shrub swamp (I4)	uncommon	*Conde*
**Salix bebbiana Sarg.*	Bebb's willow	presumably East Fen (S1)	uncommon	*Betz*
Salix candida Flueggé ex Willd.	Hoary willow	sedge meadow (S1, F2)	occasional	*Conde*
Salix discolor Muhl.	Pussy willow	shrub swamp (I1) and sedge meadow: East Fen (S1)	occasional	*Conde*
Salix eriocephala Michx.	Willow	sedge meadow: West Fen (S3)	occasional	*Conde*
Salix exigua Nutt.	Sandbar willow	calcareous seep in gravel pit (G)	uncommon	*Broersma*
****Salix fragilis L.***	Crack willow	disturbed ground in old sand mine (U4)	uncommon	*Conde*
Salix myricoides Muhl.	Blueleaf willow	sedge meadow: East Fen (S1)	uncommon	*4023*
Salix nigra Marsh.	Black willow	edges of ponds and sedge meadow/shrub-carr	occasional	*Betz*
Salix sericea Marsh.	Silky willow	sedge meadows	occasional	*Kelley*
Salix serissima (Bailey) Fern.	Autumn willow	sedge meadow: East Fen (S1)	uncommon	*4220*
Sauruaceae (Lizard's-tail Family)				
Saururus cernuus L.	Lizard's-tail	seasonally-inundated bottoms of Kalamazoo River floodplain	locally common	*Conde*
Saxifragaceae (Saxifrage Family)				
Chrysosplenium americanum Schwein. ex Hook.	Golden saxifrage	seepy shrub swamp near lobe in Source Marsh (E2) and along Kalamazoo River floodplain	locally abundant	*Conde*
Mitella diphylla L.	Bishop's cap	beech-maple and floodplain forest, especially on wetter, seepy edges and in adjacent shrub swamp	uncommon	*Assadi/Shub*
Parnassia glauca Raf.	Grass-of-Parnassus	sedge meadow: West Fen (S3)	occasional	*Conde*
Saxifraga pensylvanica L.	Swamp saxifrage	sedge meadows	occasional	*Conde*
Tiarella cordifolia L.	Heart-leaved foamflower	beech-maple forest: Pioneer Woods (C4)	rare	*Photo*

Scrophulariaceae (Figwort Family)				
Agalinis purpurea (L.) Pennell	Purple gerardia	calcareous seep in sedge meadow: Source Marsh (E2)	uncommon	*7081*
Chaenorhinum minus (L.) Lange	Dwarf snapdragon	along railroad (RR)	occasional	*4121*
Chelone glabra L.	Turtlehead	sedge meadows, shrub swamp and swamp forest in floodplains	occasional	*Adams*
Collinsia verna Nutt.	Blue-eyed Mary	hillside in beech-maple forest: Cooper's Glen (C1)	locally abundant	*Assadi/Shub*
Linaria vulgaris P. Mill.	Butter-and-eggs	Kalamazoo River floodplain (F1) and hayfield (H4)	uncommon	*Conde*
Mimulus ringens L.	Monkey-flower	sedge meadows and pond margins	occasional	*Gibson*
Pedicularis canadensis L.	Wood-betony	sandy/gravelly soil on esker	occasional	*Assadi/Shub*
Pedicularis lanceolata Michx.	Swamp-betony	sedge meadows	occasional	*Conde*
Scrophularia lanceolata Pursh	Early figwort	border of shrub swamp (I1)	uncommon	*LaBatt*
Scrophularia marilandica L.	Late figwort	beech-maple forest	occasional	*Conde*
Verbascum blattaria L.	Moth mullein	disturbed areas throughout	uncommon	*Assadi/Shub*
Verbascum thapsus L.	Common mullein	disturbed areas throughout	occasional	*Gibson*
****Veronica arvensis L.***	Corn speedwell	disturbed areas	uncommon	*Conde*
****Veronica filiformis Sm.***	Birds-eye	disturbed areas	uncommon	*Conde*
Veronica officinalis L.	Common speedwell	old-fields, shrub thickets, and conifer plantings	uncommon	*3091*
Veronica serpyllifolia L.	Thyme-leaved speedwell	young forests and old-fields	uncommon	*Assadi/Shub*
Simaroubaceae (Quassia Family)				
Ailanthus altissima (P. Mill.) Swingle	Tree-of-heaven	poplar planting (A3), young beech-maple forest, well-established in gravel pit (G)	locally common	*Conde*
Solanaceae (Nightshade Family)				
Physalis heterophylla Nees	Clammy ground-cherry	shrub thicket (U7) and gravel pit (G)	uncommon	*7127*
Physalis longifolia Nutt.	Long-leaved ground-cherry	shrub thickets	uncommon	*Conde*
Solanum carolinense L.	Horse nettle	disturbed areas: hayfields, old-fields, shrub thickets	occasional	*LaBatt*
Solanum dulcamara L.	Bittersweet nightshade	wet ground of all kinds, especially shrub-carr; also in moist shrub thickets and old-fields	occasional	*Assadi/Shub*
Solanum ptychanthum Dunal	Black nightshade	Kalamazoo River floodplain (F2) and pond margin (Pond 06)	occasional	*Walter*
Sparganiaceae (Bur-reed Family)				
Sparganium americanum Nutt.	American bur-reed	sedge meadows and emergent marsh	locally common	*4293*
Sparganium chlorocarpum Rydb.	Bur-reed	sedge meadows and emergent marsh	locally common	*Lewis*
Staphyleaceae (Bladdernut Family)				
Staphylea trifolia L.	Bladdernut	Kalamazoo River floodplain forest	locally common	*Conde*
Tiliaceae (Linden Family)				
Tilia americana L.	Basswood	beech-maple and floodplain forests, sedge meadows and shrub swamps, pioneering in some old-fields	occasional	*Walter*
Typhaceae (Cat-tail Family)				
Typha latifolia L.	Broad-leaved cat-tail	sedge meadows and emergent marsh	locally common	*Conde*

Latin Name	Common Name	Habitat (Compartments)	Abundance	Collectors
Ulmaceae (Elm Family)				
Celtis occidentalis L.	Hackberry	beech-maple and floodplain forest and some adjacent old-fields	uncommon	*Conde*
Ulmus americana L.	American elm	beech-maple and floodplain forest and some adjacent old-fields and other disturbed areas	occasional	*Norris*
Ulmus pumila L.	Siberian elm	disturbed areas: poplar planting (A1) and shrub thickets	uncommon	*7091*
Ulmus rubra Muhl.	Slippery elm	beech-maple and floodplain forest, sedge meadows and some adjacent old-fields and other disturbed areas	occasional	*Conde*
Ulmus thomasii Sarg.	Rock elm	successional beech-maple forest and terrace in Kalamazoo River floodplain (F2)	rare	*7140*
Urticaceae (Nettle Family)				
Boehmeria cylindrica (L.) Sw.	False nettle	sedge meadows, emergent marsh, mucky floodplains, shrub swamps and pond margins	occasional	*Adams*
Laportea canadensis (L.) Weddell	Wood nettle	moist beech-maple and floodplain forest, shrub swamps	common	*Conde*
Pilea fontana (Lunell) Rydb	Bog clearweed	sedge meadow, shrub-carr, and swamp forest	common	*7138*
Pilea pumila (L.) Gray	Clearweed	beech-maple and floodplain forest, shrub swamp	common	*Conde*
Urtica dioica L.	Nettle	moist old-fields and forest margins, swamp forest	occasional	*Conde*
Verbenaceae (Vervain Family)				
Phryma leptostachya L.	Lopseed	beech-maple and floodplain forest	uncommon	*Conde*
Verbena hastata L.	Blue vervain	sedge meadow, pond margins, moist old-fields	occasional	*Gibson*
Verbena urticifolia L.	White vervain	disturbed areas, margins of forests and sedge meadows	uncommon	*Conde*
Violaceae (Violet Family)				
**Viola blanda Willd. var. palustriformis Gray*	Hairy white violet	beech-maple forest edge along railroad	uncommon	*Assadi/Shub*
Viola canadensis L.	Canada violet	beech-maple and floodplain forests	occasional	*Assadi/Shub*
Viola conspersa Reichenb.	Dog violet	beech-maple and floodplain forests	uncommon	*Conde*
Viola cucullata Ait.	Marsh violet	sedge meadows, shrub-carr, and shrub swamps	common	*Assadi/Shub*
Viola pubescens Ait.	Yellow violet	beech-maple and floodplain forests	common	*Betz*
Viola rostrata Pursh	Long-spurred violet	beech-maple and floodplain forests	uncommon	*Meininger*
Viola sororia Willd.	Common blue violet	beech-maple and floodplain forests	occasional	*Betz*
**Viola striata Ait.*	Pale violet	young beech-maple forest	uncommon	*Assadi/Shub*
Vitaceae (Grape Family)				
Parthenocissus quinquefolia (L.) Planch.	Virginia creeper	forested habitat of all kinds, and adjacent old-fields	common	*Prentice*
Vitis aestivalis Michx.	Summer grape	poplar plantings, dry/gravelly beech-maple forest, margin of floodplain forest and railroad, sandy shrub thicket	occasional	*7137*
Vitis riparia Michx.	Riverbank grape	beech-maple and floodplain forests, sedge meadows, and adjacent disturbed areas and old-fields	common	*Assadi/Shub*

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On the cover: Display of spring ephemeral wildflowers along the Beech-Maple Trail at the Kalamazoo Nature Center. *Collinsia verna* (blue-eyed Mary), *Claytonia virginica* (spring-beauty), and *Dicentra cucullaria* (Dutchman's-breeches) dominate the field of view.

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DEMOGRAPHY OF OLD-GROWTH WHITE PINE STANDS AT THE HURON MOUNTAIN CLUB RESERVE AND ESTIVANT PINES IN UPPER MICHIGAN

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ABSTRACT

Few old-growth white pine (*Pinus strobus*) stands remain in the Upper Midwest after the lumbering era. White pine shows poor recruitment in mature mesic stands. Long-term studies are needed to examine succession in these forests and the ability of white pine to reproduce. I established permanent plots and examined forest demography in two preserved forests in Upper Michigan. Adjacent 1.54- and 0.92-ha plots in the Huron Mountain Club Reserve included a white pine-hemlock (*Tsuga canadensis*)-hardwood forest and an atypical white pine-white spruce (*Picea glauca*) stand with dense undergrowth of sugar maple (*Acer saccharum*) saplings. At Estivant Pines a 0.78-ha plot contained a stand of white pine-sugar maple-balsam fir (*Abies balsamea*), while a second 0.75-ha plot held a similar stand with large gaps. All stems ≥ 5 cm dbh were measured and mapped and small saplings (1–4.9 cm dbh) were tallied in transects. Only the Huron white pine-white spruce stand showed a broad size distribution of white pine trees (but no saplings) that indicated dominance well into the future. White pine trees in the other plots were virtually limited to large emergents above a maple or hemlock canopy. Only the Estivant gap site contained a number of white pine saplings but these face competition with eight other sapling species to reach the canopy. Future results in these long-term permanent plots will track the ability of white pine to persist in these forests, to see if small gaps or other factors allow episodes of reproduction without a major disturbance.

KEYWORDS: *Pinus strobus*, Huron Mountains, Estivant Pines, forest succession, tree demography

INTRODUCTION

White pine (*Pinus strobus*) forests are a symbol of Michigan's north woods. Almost all of the original mature pine forests were harvested in the lumbering era. Most of the remaining old-growth white pine stands show poor recruitment, which is a barrier to maintenance or restoration of this once major part of regional ecosystems (Carleton et al. 1996; Peck and Zenner 2009). While some argue that white pine requires a major disturbance to establish in mature forests (Frelich 1992; Carleton et al. 1996; Weyenberg et al. 2004), others report that it can remain in old-growth stands via gap-phase replacement (Hibbs 1982; Holla and Knowles 1988; Quinby 1991).

In the late-successional mesic forests of the northern Great Lakes region, most white pines are found as emergent trees above a closed canopy that is dominated by hemlock (*Tsuga canadensis*) or sugar maple (*Acer saccharum*). As succession proceeds, white pine may be replaced by hemlock or shade-tolerant

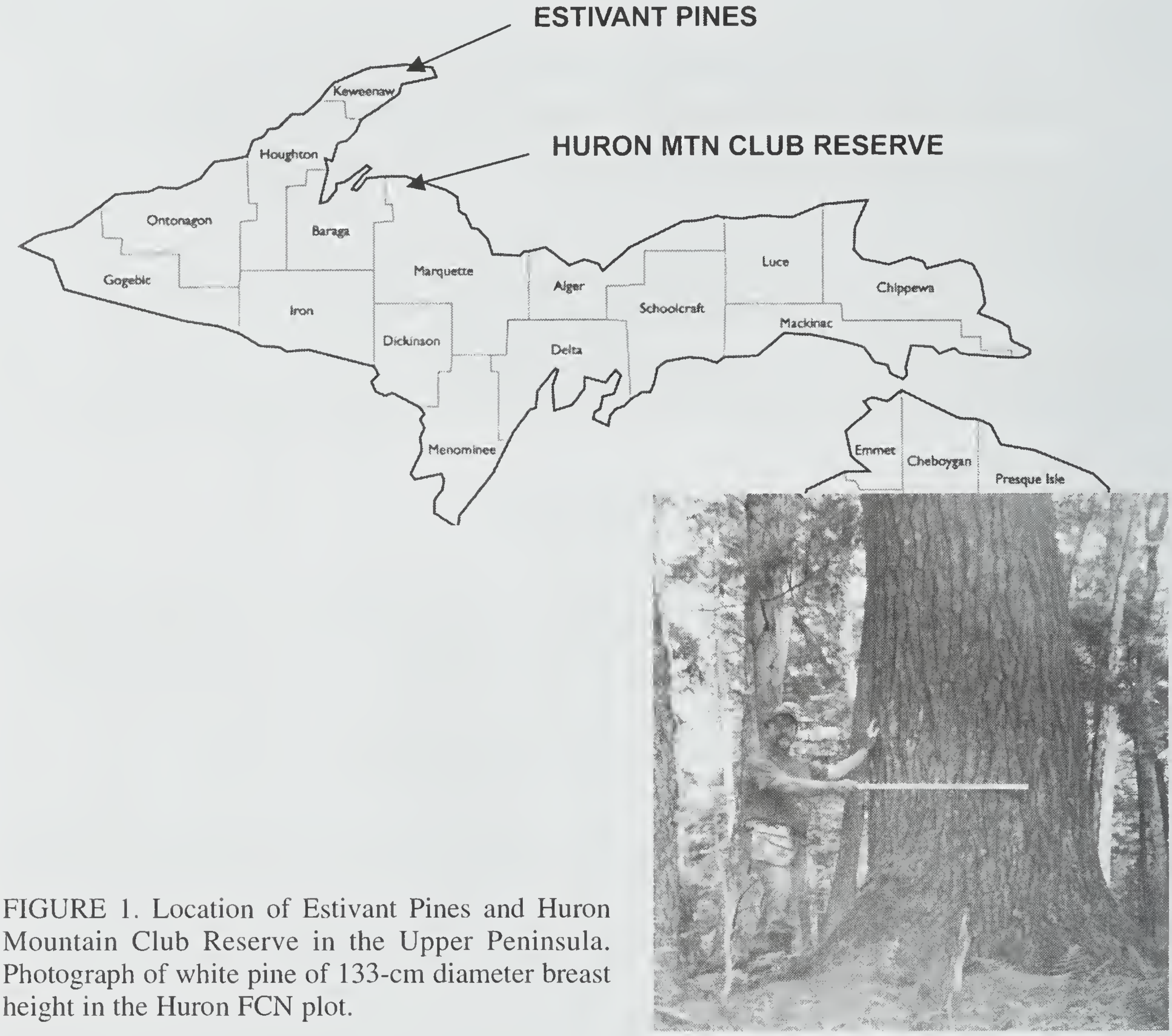
ESTIVANT PINES
HURON MTN CLUB RESERVE
Keweenaw
Houghton
Ontonagon
Gogebic
Baraga
Iron
Marquette
Dickinson
Menominee
Alger
Delta
Schoolcraft
Luce
Mackinac
Chippewa
Emmet
Cheboygan
Presque Isle

FIGURE 1. Location of Estivant Pines and Huron Mountain Club Reserve in the Upper Peninsula. Photograph of white pine of 133-cm diameter breast height in the Huron FCN plot.

hardwoods (Braun 1950; Curtis 1959). However, white pine is long-lived and can remain for many decades as a component of white pine-hardwood or hemlock-white pine-hardwood forests (Braun 1950; Abrams 2001).

Successional patterns in forests are mostly inferred from the demographic structures or chronosequence studies of various stands. The chronosequence method with substitution of space for time is problematic. Johnson and Miyanshi (2008) reported that conclusions from some classic chronosequence studies were shown to be invalid by later empirical evidence. Long-term replicated studies in forests are needed to test the theoretical patterns and to suggest additional hypotheses on late-successional dynamics (Bakker et al. 1996, Woods 2000, Legendre et al. 2009; Katz et al. 2010).

As part of a long-term study of late-successional white pine stands in Upper Michigan and northern Wisconsin, I established four permanent plots at two preserved sites in Michigan's Upper Peninsula: the Huron Mountain Club Reserve and Estivant Pines on the Keweenaw Peninsula. This paper (1) compares demography among these mature white pine stands with emphasis on its implications for succession and for pine regeneration and (2) presents size-class distribution tables that will serve as a benchmark for future studies of successional and reproductive dynamics of these forests.

MATERIALS AND METHODS

Study areas

The Huron Mountain Club has maintained a 2500-ha reserve for over a century in Michigan's Huron Mountains that border Lake Superior (Figure 1). The reserve contains extensive forests of old-growth mesic hemlock and hardwoods, which have been the subject of several studies over the years (Braun 1950; Willis and Coffman 1975; Woods 2000; Woods 2008; Marx and Walters 2008). Old-growth white pine stands are uncommon in the mesic forests of the Huron Mountains, but scattered emergent pines are a component of many hemlock-northern hardwoods stands in the Upper Midwest. During 2007–2008, I established two adjacent permanent plots totaling 2.5 ha by Fisher Creek in the Huron Mountain Club Reserve, located within 46°51.4′–51.6′ N and 87°52.9′–53.1′W. Plot maps are on file in reports to the Huron Mountain Wildlife Foundation (www.hmwf.org). The north plot (FCN) covered 1.58 ha of white pine-hemlock-northern hardwood forest, which included a few canopy gaps of 0.02-0.03 ha. The adjacent 0.92-ha south plot (FCS) contained an atypical white pine-white spruce stand that was described by Thompson (1985) and Simpson et al. (1990). Fahey (2011) reported that the oldest white pine among core samples at the Fisher Creek stands was ~210 y. FCN and FCS were similar in elevation and topography (little relief). Most of FCS soils were classified as Evart-Pelskie-Sturgeon complex with deep, poorly drained, permeable soils that form in silty and sandy alluvium and most of FCN as Kalkalska-Waiska complex of deep, well-drained, permeable soils on sandy outwash (Schwenner 2007).

Estivant Pines is the largest preserved tract of old-growth white pine in Michigan, located in a 206-ha sanctuary of the Michigan Nature Association, south of Copper Harbor near the tip of the Keweenaw Peninsula (Figure 1). This important stand lacks previous demographic study. During 2010, I established a 0.78-ha permanent plot (EPU) in a white pine stand known as Cathedral Grove. This upland plot followed the top of a broad ridge. A second 0.75-ha plot (EPG) was established to the west on a lower plateau, separated from EPU by a 20–30 m wide ravine. The Estivant plots were located within 47°26.2′–26.4' N and 87°52.8′–53.1′W. Estivant plot maps are on file in reports to the Michigan Nature Association (www.michigannature.org). EPG was chosen because it contained large gaps (0.03-0.06 ha) in the forest canopy and a number of white pine saplings and seedlings, which were rare elsewhere in Estivant Pines. Below the emergent pines at Estivant, sugar maple and balsam fir were dominant. The oldest pine sampled in the plots by Fahey (2011) was ~260 y. EPU sloped gradually downhill from northeast to southwest, but with a low aspect that is unlikely to differ in vegetation effects from the flatter EPG. Soils at both EPU and EPG were classified as Arcadian-Dishno-rock outcrop complex of cobbly and gravelly fine sandy loams (Tardy 2006).

Methods

Within the plots all living stems ≥ 5 cm were mapped by recording the x and y coordinates of each stem with a grid of measuring tapes. Stem diameters were measured at breast height (1.4 m). For mortality data, snags (dead stems) ≥ 20 cm dbh (diameter breast height) were also mapped and measured. Along transect lines running across the plots, small saplings (= 1.0–4.9 cm dbh) were tallied by species in a continuous strip of 2- × 4-m quadrats (all stems ≤ 2 m from the lines). Transect lines were mostly located along N-S and E-W lines (with a few exceptions that followed major plot axes), spread out to cover all sections of the plots. Some transect locations in FCN and EPG were chosen to pass through canopy gaps to monitor long-term changes in tree regeneration within the gaps. This likely biases the sapling densities reported for these plots. Transect lengths totaled 652 m in FCN, 290 m in FCS, 312 m in EPU, and 392 m in EPG. Size class distributions of all individual living stems were tabulated for this paper for demographic analysis and to provide a record for ecologists who revisit the permanent plots in the future. Nomenclature follows Barnes and Wagner (2004).

RESULTS

At the Fisher Creek site of the Huron Mountain Reserve, FCN was covered by a hardwood-white pine-hemlock (in order of basal area) forest (Table 1). White pine dominated the larger size classes; most pines were emergent over a

TABLE 1. Species size class distribution and basal area of Huron Mountain Club Fisher Creek 1.54–ha North (FCN) and 0.92-ha South (FCS) plots.

	Number of stems in size class (cm dbh)													
	5-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91-100	101-110	111-120	131-140	basal area m^2/ha
FCN														
Pinus strobus			2			4	2	5	4	10	7	1	1	14.2
Tsuga canadensis	12	64	76	53	25	9	4	2						12.2
Acer saccharum	21	12	21	19	35	24	21	5						15.3
Acer rubrum			4	4	8	4								1.9
Betula alleghaniensis		7	40	46	14	5								6.4
Betula papyrifera					1	1								0.3
Picea glauca	36	32	6	2	1									0.9
Abies balsamea	16	27	7											0.7
Thuja occidentalis			5	5	3									1.0
Tilia americana		1	1											0.0
Populus grandidentata			1											0.0
Ostrya virginiana	28	10												0.2
Acer pensylvanicum	8													0.0
FCS														
Pinus strobus		5	9	11	13	26	18	11	1	1				31.3
Tsuga canadensis		6	4	2	1									0.9
Acer saccharum	136	14	1				2							1.7
Acer rubrum	1	4	1	8	4	4	1		1					4.8
Betula alleghaniensis	1	2	2	4										0.8
Picea glauca	2	11	19	14	8	4	1							7.1
Abies balsamea	6	12	3											0.6
Ostrya virginiana		1												0.0
Acer pensylvanicum	2													0.0

TABLE 2. Small saplings (stems = 1-4.9 cm dbh) per ha on study plots from transect samples. FCN = Fisher Creek North, FCS = Fisher Creek South, EPU = Estivant Pines Upland, EPG = Estivant Pines Gap.

	FCN	FCS	EPU	EPG
Pinus strobus				128
Acer saccharum	125	2052	40	51
Acer rubrum			112	83
Quercus rubra			88	191
Betula alleghaniensis			48	153
Picea glauca	36		32	6
Abies balsamea	3		753	1595
Thuja occidentalis			577	198
Ostrya virginiana	150	26	8	32
Acer pensylvanicum	23	15		

closed canopy of sugar maple and hemlock. Sugar maple dominated the 41–80 cm size classes. Hemlock and, to a lesser extent, yellow birch (*Betula alleghaniensis*) were most abundant in the 11–40 cm range. White spruce (*Picea glauca*) and balsam fir were abundant in the smallest classes (5–20 cm).

FCS contained a white pine-white spruce-red maple (*Acer rubrum*) stand with dense undergrowth of sugar maple saplings FCS lacked the closed hemlock-maple canopy of FCN, as hemlock was a minor component of the stand. White pine trees were more dense in FCS (103/ha) than FCN (23/ha), but smaller in average size (Table 1). White pine was dominant among trees > 40 cm dbh. White spruce was the most abundant species among 21–40 cm stems. However, many recently-fallen white spruce of this size were present in FCS, indicating that the relative importance of spruce in the stand is decreasing. Sugar maple dominated FCS stems ≤ 20 cm (Tables 1, 2) and formed dense sapling thickets.

At Estivant Pines, white pine dominated the upland EPU site with sugar maple the leading hardwood associate (Table 3). Balsam fir and white cedar (*Thuja occidentalis*) formed a dense subcanopy. Reflective of its gaps, the total basal area of EPG was 19.9 m^2/ha less than EPU (34.7 vs. 54.6 m^2/ha), mostly due to a 19.5 m^2/ha decrease in white pine basal area (Table 3). Although one might expect more snags in the gap area, the number of snags of large white pine (51–90 cm dbh) was similar in EPG (n = 8) and EPU (n = 7) but the total number of snags of all species ≥ 20 cm dbh was greater in EPU (n = 39) than EPG (n = 35). There was no obvious evidence of a windthrow event or other major disturbance that may have caused the large gaps in EPG. The hardwood component of EPG and EPU was similar, though red oak (*Quercus rubra*) and red maple were more common in EPG (Table 3). Balsam fir saplings formed dense thickets in EPG. Small fir saplings (1.0–4.9 cm dbh) were twice as thick in EPG as EPU (Table 2). White cedar was less abundant in the subcanopy in EPG than in EPU (Tables 2, 3).

White pine reproduction was uncommon at the study sites. Pine saplings < 5 cm dbh were only found in the transects of the EPG plot (Table 2). EPG also contained 16 white pines of 5–10 cm dbh (but no stems of 11–78 cm). EPU only had one white pine in the 5–10 cm size class (with no stems of 7–51 cm). FCN

TABLE 3. Species size class distribution and basal area of Estivant Pines 0.78-ha upland (EPU) and 0.75-ha gap (EPG) plots.

	Number of stems in size class (cm dbh)													
	5–10	11–20	21–30	31–40	41–50	51–60	61–70	71–80	81–90	91–100	101–110	111–120	131–140	basal area m^2/ha
EPU														
Pinus strobus	1					4	6	8	8	8	3			25.0
Acer saccharum	32	78	75	28	8	2								12.5
Acer rubrum	13	9	8	3	6	1								2.8
Quercus rubra	19			1										0.2
Betula alleghaniensis	7	2		1	1	3	1							1.9
Betula papyrifera		1	2	1										0.3
Picea glauca	1		1	1										0.4
Abies balsamea	417	264	14											8.2
Thuja occidentalis	57	33	20	7	1									3.3
Ostrya virginiana	1													0.0
EPG														
Pinus strobus	16							2	1	2		1		5.5
Acer saccharum	46	91	48	31	7									11.1
Acer rubrum	22	33	20	7	2	2								4.1
Quercus rubra	25	1	1	4	3	1								1.6
Betula alleghaniensis	16	5	1		6	1	1							2.4
Betula papyrifera	1				1									0.2
Picea glauca	3	3	5	1										0.5
Abies balsamea	547	146	4											6.1
Thuja occidentalis	19	16	14	9		1								2.9
Ostrya virginiana	23	4	1											0.3

had no white pine < 23 cm dbh (and only 2 stems < 53 cm). Of the 4 plots, only FCS showed a broad distribution among white pine size classes, but it had no stems < 15 cm. Species richness of small saplings was greater at Estivant than at the Hurons (Table 2), where the lower diversity may relate to the shaded ground cover of sugar maple saplings and seedlings. Density of small saplings was about 1.5 times greater in EPG than EPU (2437 vs. 1658 stems/ha). However, EPU contained 8 of 9 of the EPG small-sapling species, all except white pine (Table 2).

DISCUSSION

The demography of the FCN plot in the Huron Mountains fits descriptions of a "classic" hemlock-white pine-northern hardwoods forest (Nichols 1935; Braun 1950; Curtis 1959; Abrams and Orwig 1996). Tall white pine trees emerged above hemlock and sugar maple, but white pine sapling regeneration was absent in the shaded understory (Tables 1, 2). White pine is intermediate in shade tolerance and can be outcompeted by more tolerant species such as hemlock, sugar maple, and balsam fir (Wendel and Smith 1990). Sugar maple, hemlock, and yellow birch may benefit most from the FCN gaps, though Woods (2000) reported that yellow birch did not regenerate well in small gaps in the Huron hemlock-hardwood forest. Woods found a gradual increase in hemlock dominance in a set of permanent plots from 1972 to 1994. Hemlock dominance will also likely increase at FCN over the next decades, although if the lack of hemlock regeneration continues, this species may decline thereafter. Herbivory by deer may be a factor in inhibition of hemlock regeneration (Anderson and Loucks 1979, Rooney and Waller 2003). Deer populations have increased in recent decades in the Upper Peninsula (Doepker et al. 1995). White spruce is a major component of the understory at FCN. However, spruce sapling mortality was noted beneath shaded areas of maple-hemlock, indicating that spruce may have difficulty establishing into the canopy. White spruce is intermediate in shade tolerance in northern mesic forests (Nienstadt and Zasada 1990).

A white pine-white spruce-red maple stand, as found at FCS, is not recognized as a common forest association (Eyre 1980; Wendel and Smith 1990). White spruce can colonize disturbed areas as a pioneer species but can also be found as a minor component of mature northern mesic forests (Curtis 1959; Eyre 1980; Burns and Honkala 1990). Possible explanations for the white spruce prevalence over hemlock in FCS include past disturbance and soils. Simpson et al. (1990) noted the ability of white spruce and balsam fir to colonize a nearby area in the Fisher Creek basin after the clearcutting of a white pine-hemlock-northern hardwood stand. However, no obvious evidence of logging or fire was noted in FCS. Fahey (2011) found charcoal in soil at the Fisher Creek site to be ~350 y, predating his oldest cored white pine by more than a century. Hemlock is associated with well-drained soils, which may have inhibited its presence in FCS, where soils are mapped as poorly drained versus well drained in FCN (Schwenner 2007). Recent windthrow of individual white spruce was common in FCS, indicating that the stand may trend in future decades to a red maple, and later a sugar maple, canopy under the emergent white pine. Or, perhaps canopy gaps created by spruce mortality will increase the ability of other species to establish in the future, though this might be countered by the sugar maple sapling thicket that now darkens the forest floor. Then again, the study of Peet (1984) indicated that an understory dominated by sugar maple does not necessarily lead to canopy replacement by sugar maple. Peet noted substantial sugar maple mortality in the subcanopy of a white pine stand in Minnesota over a 26-y permanent plot study, which he attributed to deer browsing. Peet cautioned that understory hardwood succession was dynamic and not predictable from simple projection of the original stand structure.

The white pine-hardwood forest at Estivant Pines differed from the Huron FCN stand by the absence of hemlock and the presence of a dense balsam fir-white cedar subcanopy. On the Keweenaw Peninsula, Maycock (1961) reported that boreal stands of balsam fir-white spruce become more common at the northern tip, as presumably do boreal components of mixed stands. Maycock felt that undisturbed boreal forests in the Keweenaw become more dominated by balsam fir over time, as well as invaded by hardwoods, especially sugar maple. The Estivant Pines plots essentially have a three-layered canopy with white pine emergent, sugar maple dominating the middle, and balsam fir dominant below. One would project that white pine will decline in future decades while sugar maple and balsam fir increase. The balsam fir thickets of EPG have not inhibited sugar maple regeneration (Riege, unpublished data). Frank (1990) reported that individual firs suffer from strong intraspecific competition in balsam fir thickets, as well as interspecific competition from shade-tolerant hardwoods. Brown and Curtis (1952) concluded that balsam fir would be outcompeted by sugar maple in the heavy shade of mesic maple stands. The greater density of balsam fir at EPG versus EPU may be due to recent gap filling, with future years bringing self thinning of the firs, as described by Frank (1990). The greater abundance of red oak and red maple in EPG may be due to the openings or perhaps the decreased competition from white pine. No obvious difference was apparent in soils between the Estivant plots (Tardy 2006).

The atypical FCS is most likely of the four stands to maintain white pine dominance over the next century with its abundance of small trees, but if the lack of recruitment of saplings continues, longer term decline will occur. Many studies conclude that white pine requires major disturbances such as fire or windstorms for reproduction in late-successional stands (Frelich 1992; Carleton et al. 1996; Abrams 2001; Weyenberg et al. 2004), although others report the ability of white pine to recruit in canopy gaps (Hibbs 1982; Holla and Knowles 1988; Quinby 1991; Engelmark et al. 2000). In an extensive survey of regional white pine forests, Fahey (2011) found that, although most pines (white and red pine, *Pinus resinosa*) were established after large disturbances, ~35% of pines in mesic sites recruited after smaller stand-level and gap disturbances.

With the exception of FCS, white pine reproduction has been essentially absent for many decades in my study plots, as indicated by the lack of trees in the 11–50 cm size classes Tables 1, 3). This cannot be explained by paucity of seed production, since white pine begins seeding at 20-30 y and typically has good seed years every 3-5 y (Wendel and Smith 1990). White pine saplings have been able to recently establish at the EPG plot with large gaps. However, the pine saplings at EPG are in competition with saplings of eight other species (Table 2) to fill openings and face the shading of sugar maple and balsam fir as the gaps close. Carleton et al. (1996) found that seedling establishment was less critical for white pine than subsequent survival and growth in the face of competition. Abrams (2001) noted that white pine saplings have a comparatively slow growth rate in mixed species forests.

The speculations in this discussion on future stand composition from present demography must be taken with caution. A major premise of this study is that forests may not succeed as projected and long-term plot studies are needed to ascertain true dynamics (Bakken et al. 1996; Woods 2000; Johnson and Miyanishi 2008; Katz et al. 2010). I have found this to be the case in recent results from mature Wisconsin forests (Riege, unpublished data) that showed a resurgence of white pine regeneration not predicted from stand demography of the 1940s and 1970s, with no evidence of major disturbances. Long-term studies of the permanent plots in the Upper Peninsula and northern Wisconsin will address several questions on vegetation dynamics in a variety of late-successional pine forests. Do white pines regenerate in certain sites to maintain dominance in the absence of a major disturbance? If so, are large gaps required? If not, what species are successful in replacing pines as dominants? Which mesic forest associations are more conducive to white pine reproduction? Is late succession in these forests a gradual or episodic process? Results will provide benchmark data to managers who are striving to maintain or restore white pine in regional forests. It is my intent in this study that the permanent plots may yield their most valuable results to future ecologists many decades from now.

ACKNOWLEDGEMENTS

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RELIABILITY OF WISCONSIN OAK SPECIES IDENTIFICATION BASED ON HERBARIUM SPECIMENS

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ABSTRACT

Identification of oak species is an important part of natural resource science and field work, but there exists little quantitative information about the reliability of individuals to make these identifications. This study examines the reliability among forestry students and faculty at The University of Wisconsin-Stevens Point when identifying oak species from herbarium specimens. Percent agreement ranged from 10 to 100 percent and inter-rater reliability was consistently fair. Both measures were highest for graduate students, the group with consistent field experience identifying oak species and a relatively high self-perceived level of competence. These results have implications when designing experiments or comparative studies, which require observers to identify oaks to the species level, and for forestry monitoring programs, which generate trend data using different staff over long time periods.

KEYWORDS: *Quercus* section *Lobatae*, Fleiss' kappa, forestry students, percent agreement

INTRODUCTION

Researchers and workers in natural resources often identify oak trees to the species level (Johnson 1975; Stambaugh and Guyette 2008; Mujuri and Demchik 2009) and the Forest Service conducts annual surveys of forest resources that often rely on accurate identification of oak species (USDA Forest Service 2011). Quality assurance is a key component of these surveys. The reliability of oak species identifications has implications for interpretation of research findings, particularly those that rely on multiple observers and longitudinal studies. Currently there is no information in the published literature providing data regarding the agreement among observers identifying oak species.

Within North America there are three sections of the genus *Quercus* L. (Nixon 1993; Jensen 1997): section *Quercus* L., section *Protobalanus* (Trelease) A. Camus, and section *Lobatae* G. Don. Within section *Lobatae*, five distinct species are recognized in Wisconsin: scarlet oak (*Quercus coccinea* Münchh.), northern pin oak (*Quercus ellipsoidalis* E.J. Hill), pin oak (*Quercus palustris* Münchh.), northern red oak (*Quercus rubra* L.), and black oak (*Quercus velutina* Lam.) (Fewless 2004; Freckmann 2010). Fertile hybrids between members of the same section, many of which are named, are known to occur (Palmer 1942; Jensen and Eshbaugh 1976a; Cottam et al. 1982, p. 47). The presence of trees with intermediate characters, or combinations of characters, supports the presence of putative hybrids (Jensen and Eshbaugh 1976a; Jensen and Eshbaugh 1976b).

The treatment in Flora of North America (FNA) suggests that these species can be readily distinguished if mature sun leaves, twigs, and mature buds are all observable (Jensen 1997). It is recommended that multiple characters be used to make species determinations because oak species are known to demonstrate wide character variability (Jensen 1988). While many species may have distinct characters, characters may be intermediate within sympatric populations (Palmer 1942; Knops and Jensen 1980; Jensen 1988). Many authors have lamented the difficulty of separating species because characters are variable and often form a continuum of size, shape, color, and pubescence (Palmer 1942; Jensen 1977; Hipp and Weber 2009).

SPECIES IDENTIFICATION

Scarlet oak is rare in Wisconsin. The University of Wisconsin-Stevens Point (UWSP) herbarium has two putative specimens, one from Rock County and one from Oconto County. Similarly, the University of Wisconsin-Madison (UW-Madison) herbarium has three records (Cameron 2005). Scarlet oak hybridizes with black oak, producing *Q.* × *fontana* Laughlin. Scarlet oak also hybridizes with pin oak and northern red oak (Jensen 1997).

Scarlet oak "has large buds that are pubescent on the upper half, (the) inner surface of the acorn cups is glabrous to sparsely pubescent and the acorns have concentric rings at their apices" (Jensen 1977). According to FNA (Jensen 1997) scarlet oak and northern pin oak have similar characters, however, in scarlet oak the acorn cup scale margins are strongly concave, rather than straight or slightly concave, the nut is subglobose versus ellipsoid, and the nut has one or more concentric rings of pits at the apex.

Northern pin oak is common throughout Wisconsin. Northern pin oak "has small, sparsely pubescent buds, striate acorns, and the inner surface of the acorn cap (is) glabrous" (Jensen 1977). E. J. Hill (1899), in his original description of northern pin oak, stated that the species, in many characters, "suggests *Q. velutina*", and he considered the possibility of hybridization between scarlet, black or pin oak.

While pin oak is commonly planted as a street tree in southern Wisconsin, in natural settings, it is a rare tree found in wet to moist habitats. Relative to northern red oak and black oak, pin oak leaves are small and the winter-buds are small and glabrous. Compared to other Wisconsin members of section *Lobatae*, the nut is small and short with a shallow cup and small, tightly appressed scales. The inner surface of the acorn cup is sparsely pubescent (commonly only around the scar where the nut was attached), and dense tufts of fine hairs occur in the main vein axils of the lower leaf surface (Palmer 1942; Jensen 1977).

Northern red oak is found throughout Wisconsin. Some authorities, as noted by Jensen (1997), recognize two varieties: trees with large nuts with only one-fourth of the nut covered by the cup are treated as *Quercus rubra* var. *rubra* and trees with smaller nuts and one-third of the nut covered by the cup are treated as *Q. rubra* var. *borealis* (F. Michx.) Farw. Northern red oak hybridizes with pin oak (*Quercus* × *columnaris* Laughlin), black oak (*Q.* × *hawkinsiae* Sudw.), and northern pin oak (Burns and Honkala 1990; Jensen et al. 1993). Northern red oak has large, glabrous winter-buds with a tuft of tomentum at the apex, ovate leaf lobes, and the inner surface of the acorn cups is glabrous to sparsely pubescent (Jensen 1977). It often has slightly drooping leaves that differ from other members of the section by the dull green upper surface (Palmer 1942).

Black oak is restricted to the southern half of Wisconsin. Black oak hybridizes readily and named hybrids include *Q.* × *fontana* Laughlin (hybrid with *Q. coccinea*), *Q.* × *palaeolithicola* Trel. (hybrid with *Q. ellipsoidalis*), *Q.* × *vaga* Palmer & Steyerm. (hybrid with *Q. palustris*), and *Q.* × *hawkinsiae* Sudw. (hybrid with *Q. rubra*). Black oak has bright yellow inner bark, large winter-buds with grayish, pubescent scales, acorn cups with loose scales, and uniform pubescence on the inner surface of the acorn cups" (Palmer 1942; Jensen 1977).

STUDY OBJECTIVE

The objective of this study was to assess the percent agreement and the interrater reliability among forestry students and faculty at UWSP when identifying oak species. Students and faculty were asked to identify oak species from herbarium specimens that demonstrated an array of characters considered necessary to make an accurate identification.

MATERIALS AND METHODS

Ten-herbarium specimens were selected from the Robert W. Freckmann Herbarium on the campus of UWSP (Freckmann 2010). These ten specimens included five with multiple, distinct characters consistent with one of the five members of *Quercus* section *Lobatae* determined to be extant species in Wisconsin; one with multiple, distinct characters of a very familiar member of *Quercus* section *Quercus,* (bur oak, *Q. marcrocarpa* Michx.); and four with intermediate characters of the members of *Quercus* section *Lobatae.* Bur oak was included as a readily identifiable species to confirm that participants were acceptably engaged in the process. Characters were defined as distinct or intermediate based on a review of the literature (Palmer 1942; Jensen 1977; Jensen 1997; Hipp and Weber 2009). Each herbarium specimen had multiple characters represented, including abaxial and adaxial leaf surfaces, twigs with buds, and acorns (Figures 1 and 2). Each specimen included the county, date, and habitat of the collection site.

All undergraduate forestry students at UWSP are required to complete FOR232 and FOR432. The former, Dendrology and Silvics, covers the ecology and classification of common upper Midwest trees and shrubs, while the latter, Silviculture, is designed to teach the principles governing establishment, treatment, and control of forest stands. FOR232 is a prerequisite for FOR432 (UWSP 2011).

I attended all laboratory sections of FOR232 at the end of the 2010 fall semester and invited students to participate in the study during their assigned laboratory period. I invited all FOR432 students to participate in the study during two evening sessions at the end of the 2010 fall semester. These participants attended these sessions outside of their normally scheduled class time. I attended one UWSP forestry faculty meeting and invited all forestry faculty to participate in the study. All College of Natural Resource graduate students at UWSP with an emphasis in forestry were invited to participate. Faculty and graduate student participants attended one of the two evening sessions along with the FOR432 students or were provided additional opportunities at their discretion.

Participants were provided with a data sheet and asked to identify each herbarium specimen, by sight, to the species level. References and keys were not available. Data sheets included the names of all six possible species. If a specimen demonstrated intermediate characters, participants were

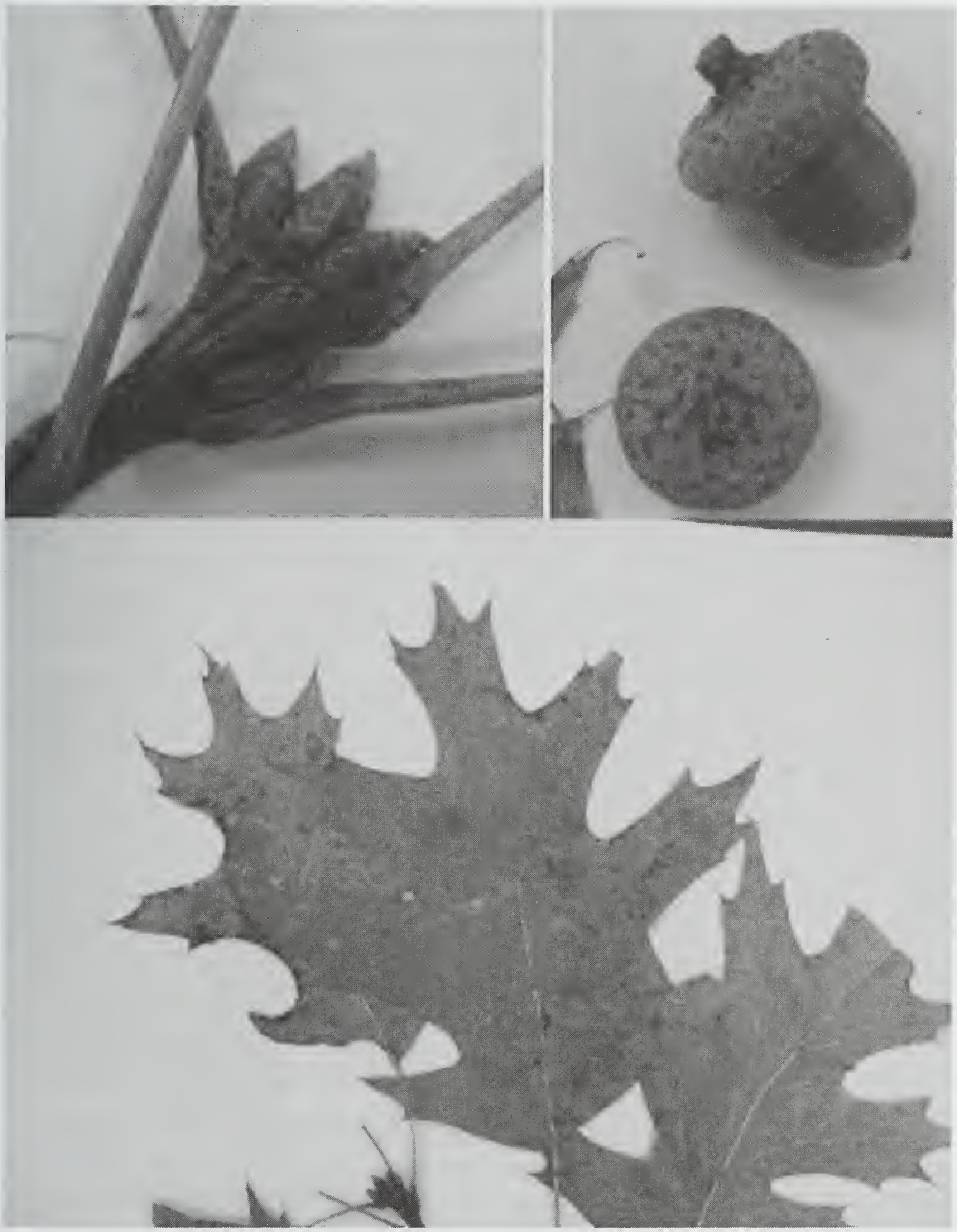

FIGURE 1. Herbarium specimen of *Quercus rubra* with multiple distinct characters. Percent agreement among graduate students was 100 percent.

asked to select the species most representative of the specimen therefore each species name could potentially be recorded multiple times. Because of the similarity in common names, participants were asked specifically to avoid confusing northern pin oak and pin oak and were directed to use scientific names. Prior to starting identification, participants were asked to rate their self-perceived level of competence. Competence was on a scale of one to ten, relative to their peers, with ten being the most competent. No time limit was placed on participants. Prior to initiation, this research was reviewed and approved by the UWSP Institutional Review Board for the Protection of Human Subjects.

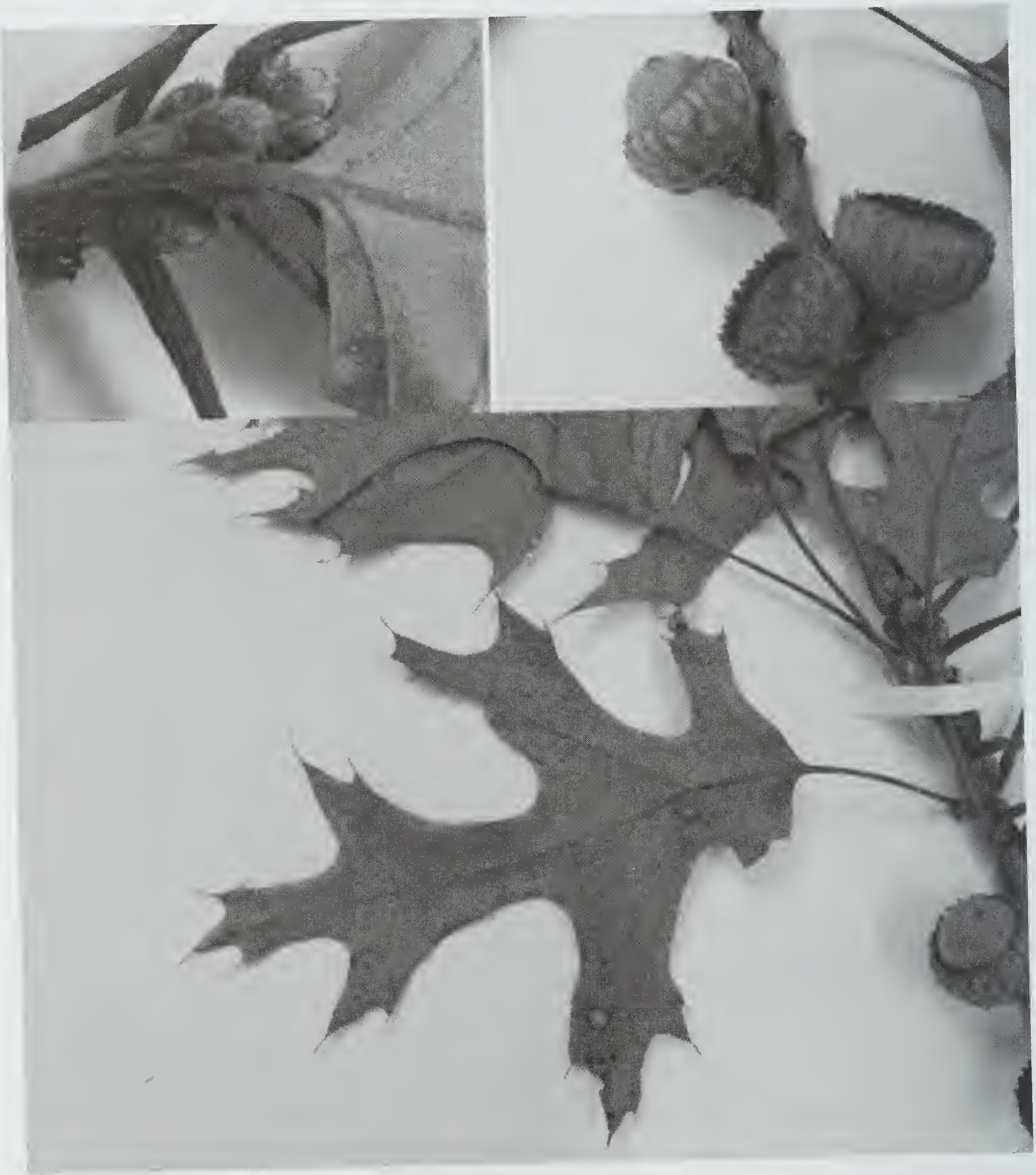

FIGURE 2. Herbarium specimen with intermediate characters. Percent agreement among graduate students was 33 percent.

STATISTICAL ANALYSIS

Percent agreement was calculated for the six specimens with multiple, distinct characters consistent with one species. Percent agreement of 100 percent means that all participants identified the specimen to the species assigned based on distinct characters. The Fleiss kappa statistic (Fleiss 1971) was calculated for all participants, for students completing FOR232, for students completing FOR432, for graduate students, and for forestry faculty. Fleiss' kappa statistic is a measure of inter-rater reliability, corrected for chance agreement (Gwet 2010,

TABLE 1. Landis and Koch kappa benchmark scale.

Kappa	Level of Agreement
<0.0	Poor
0.0 to 0.20	Slight
0.21 to 0.40	Fair
0.41 to 0.60	Moderate
0.61 to 0.80	Substantial
0.81 to 1.00	Almost perfect

p. 26–28). Inter-rater reliability was calculated for all ten specimens and for the six specimens with multiple, distinct characters consistent with one species. A kappa coefficient of 1.00 means perfect agreement and a value of 0.00 means agreement equal to chance alone. The benchmark scale proposed by Landis and Koch (1977) was used to characterize the degree of agreement (Table 1).

RESULTS

Based on the entire population available for this study, participation was high among three of the four groups (Table 2). Percent agreement for the six specimens with distinct characters ranged from 10 to 100 percent (Figure 3). Percent agreement between graduate students was at or above 75 percent for five of the six specimens. Fifty percent of graduate students identified the northern pin oak (qe) specimen as black oak (qv) (Figure 4). By accepting black oak (qv) or northern pin oak (qe) for the specimens assigned northern pin oak (qe) and black oak (qv), respectively, the percent agreement increased substantially for most cases. FOR432 students identified the northern pin oak and the black oak specimens as pin oak (qp) 47 percent of the time. The specimen identified as pin oak (qp) was identified as scarlet oak (qc) 47, 47, and 37.5 percent of the time by FOR232, FOR432, and faculty, respectively. The specimen identified as scarlet oak (qc) was identified as black oak (qv) by 33 percent of FOR432 students and

TABLE 2. Fleiss' kappa statistic for assessing inter-rater reliability, corrected for chance agreement. Raters assigned a species name to each of ten specimens. A list of six possible species names was provided to the raters. Six of the ten specimens had multiple characters consistent with one species and are listed as "specimen with good characters". Self reported competence, relative to peers, is on a scale of one to ten with ten being the most competent.

Rater status	Number of raters	Percent participation	All specimen	Specimen with good characters	Self perceived competence	
			kappa	kappa	median	range
All	106		0.27	0.33	6	1–9
FOR 232	79	80	0.28	0.34	6	1–9
FOR 432	15	21	0.27	0.24	5.5	3–9
Graduate students	4	100	0.39	0.66	7	5–8
Forestry faculty	8	73	0.33	0.42	5	1–9

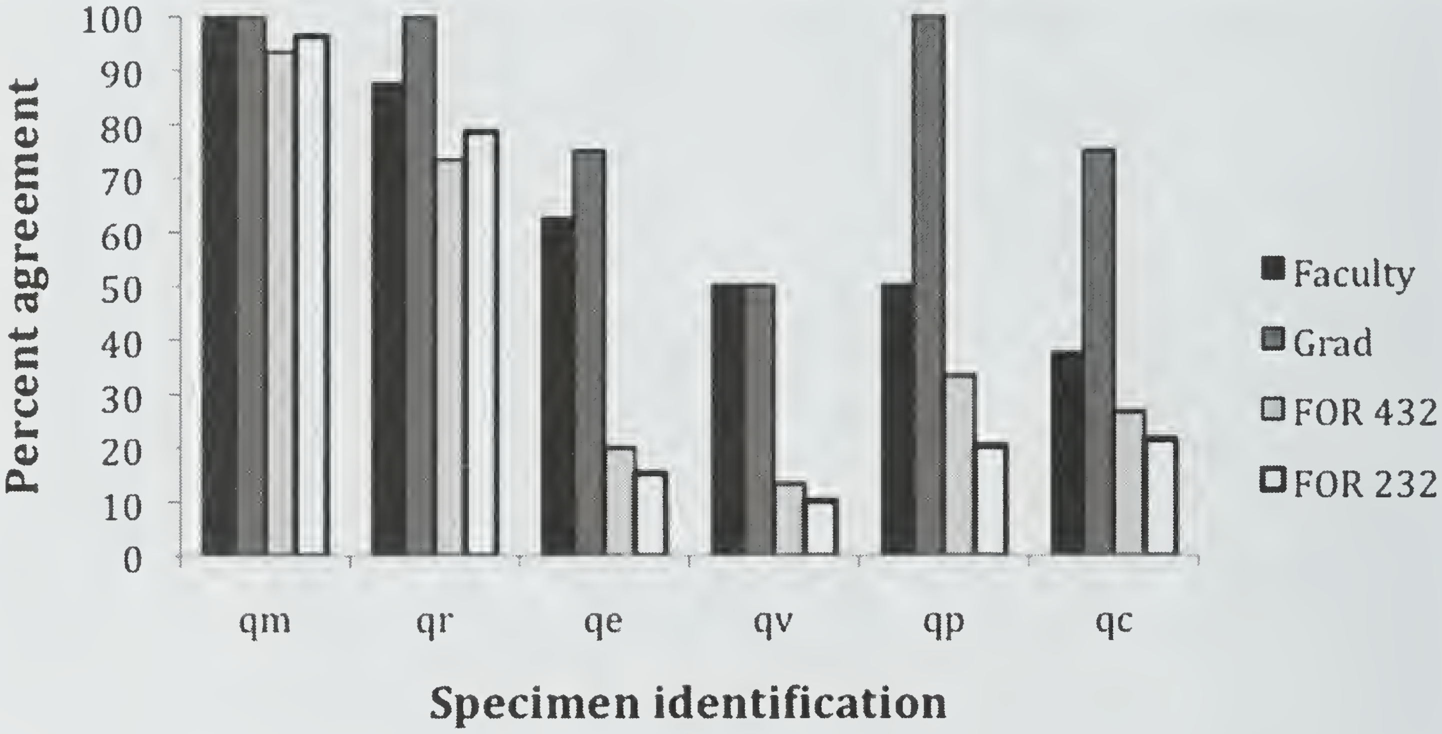

FIGURE 3. Percent agreement is the percent of raters in each group that correctly identified the six specimens with multiple characters consistent with that species. Participants were stratified as faculty, graduate students (Grad), students completing FOR 432 (FOR 432), and students completing FOR 232 (FOR 232). Species are bur oak (qm), northern red oak (qr), northern pin oak (qe), black oak (qv) pin oak (qp), and scarlet oak (qc).

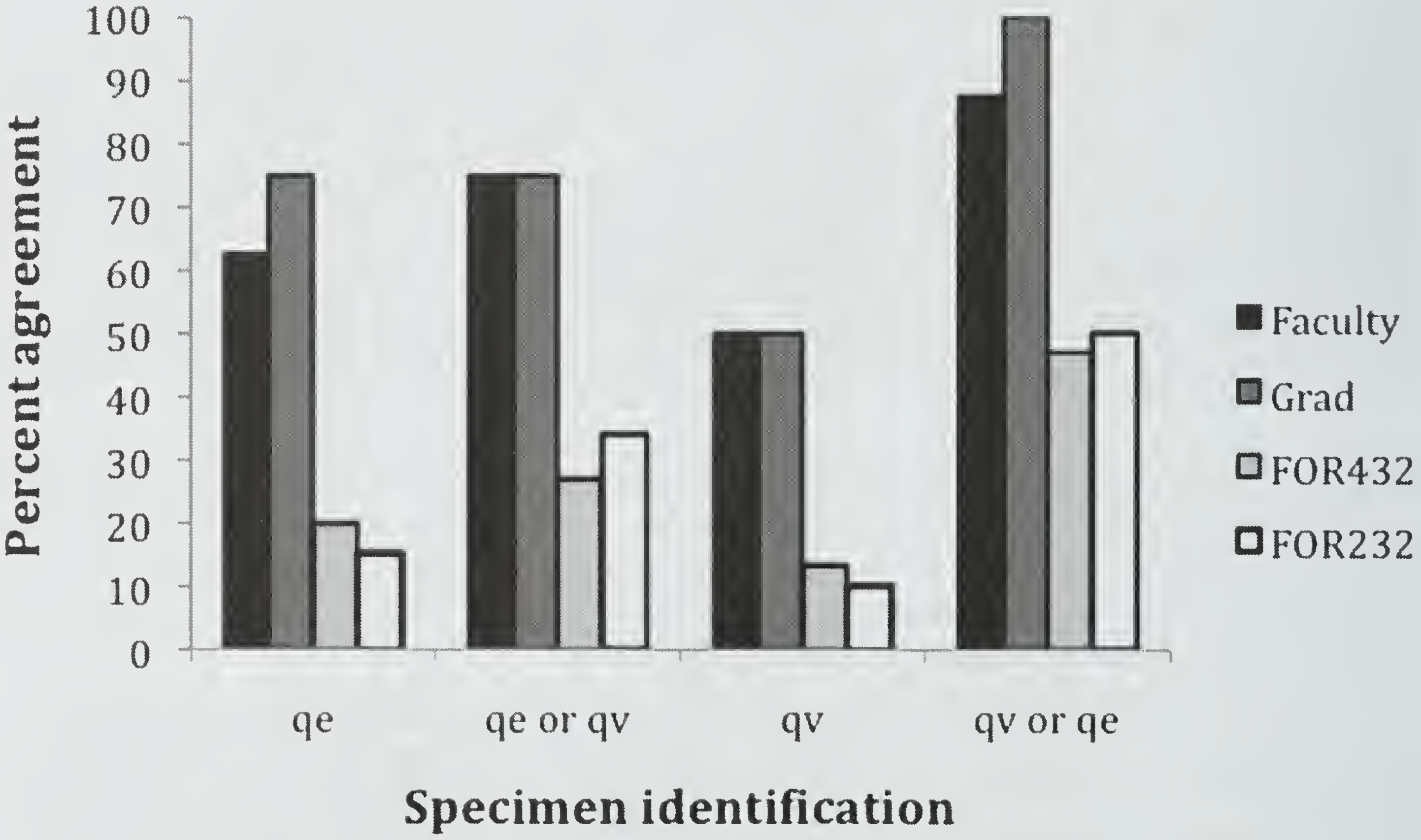

FIGURE 4. Percent agreement is the percent of raters in each group that correctly identified the specimen. Participants were stratified as faculty, graduate students (Grad), students completing FOR 432 (FOR 432), and students completing FOR 232 (FOR 232). Species are northern pin oak (qe), and black oak (qv). By accepting qv or qe for specimen qe and qv, respectively, the percent agreement increased substantially for most cases.

50 percent of faculty. Inter-rater reliability was consistently fair (Table 2). Inter-rater reliability for the six specimens with distinct characters was moderate for forestry faculty and substantial for graduate students. Graduate students had the highest median self-perceived competence and forestry faculty had the lowest (Table 2).

DISCUSSION

The Cohen kappa statistic was introduced to measure the degree of agreement between two observers for nominal scale data (Cohen 1960). Fleiss extended this statistic to the measurement of agreement among multiple observers (Fleiss 1971). Initially applied to psychiatric diagnosis, the Fleiss' kappa coefficient is commonly used to assess the inter-observer reliability of various classification systems in the medical literature (Brumback and Jones 1994; Malek et al. 2006; Maripuri et al. 2008). Orthopedic surgeons, who are highly trained professionals, categorize fractures based on accepted radiographic criteria. The mean kappa value among orthopedic surgeons classifying a common fracture was 0.61 (Malek et al. 2006). The kappa coefficient has also been used in natural resources, e.g., to evaluate inter-observer agreement between volunteers and experts for amphibian point counts conducted in Ontario, Canada. The kappa coefficient was approximately 0.75, which the authors interpreted as good to strong agreement among observers (Shirose et al. 1997). More commonly, natural resource investigators have reported percent correct or percent agreement based on a standard (Genet and Sargent 2003; Pierce and Gutzwiller 2007). Volunteers doing frog and toad surveys in Michigan were evaluated by mail survey which included a questionnaire and an audio CD. Twelve sites were represented on the CD and volunteers correctly identified species greater than 80 percent of the time for most sites. However, on six of the twelve sites responses significantly differed from correct identifications. Ability to make correct identification was not related to experience (Genet and Sargent 2003). Two trained observers in Texas agreed on the species identification during 269 frog call surveys 79 percent of the time (Pierce and Gutzwiller 2007).

The reliability of species identification in forestry has not been examined closely. Data collection by volunteers in Brookline, MA has been studied as part of an urban forestry initiative (Bloniarz and Ryan III 1996). Ninety-seven volunteers were recruited from the community and participated in a twelve-hour training program. Volunteers documented the species of 11,250 trees. Two certified arborists re-examined 473 randomly chosen trees. Percent agreement between the volunteers and the arborists was greater than 90 percent at the genus level and ranged from 46 to 96 percent at the species level (70 percent for *Quercus* spp.). Genera included were *Acer* L., *Fraxinus* L., *Quercus, Platanus* L., *Gleditsia* L., and *Tilia* L.

In the winter of 2010/11, I examined the entire collection of *Quercus* section *Lobatae* in the Robert W. Freckmann Herbarium (Freckmann 2010) on the campus of UWSP (unpublished data). Protocol requires that the curator review all specimens prior to placement in the herbarium. I examined 406 specimens and 46 were annotated by me based on the literature reviewed in the “species identification” section above. The most common reclassification, 25 specimens, was from northern pin oak to black oak.

The identification of oak species can be complicated by many factors and multiple characters may be necessary to make the identification (Jensen 1997). Oak leaves show substantial differences in sun and shade leaves (Barnes and Wagner Jr. 2007, p. 9–11), and hybrids may have intermediate characters (Palmer 1942; Jensen and Eshbaugh 1976a; Jensen 1988; Jensen et al. 1993). Site conditions may also contribute to heterogeneity. In the field certain characters may not be present at the time of identification or may be inaccessible (Barnes and Wagner Jr. 2007). During vegetative monitoring, individuals of *Quercus* section *Lobatae* are often treated as one category because of difficulty distinguishing the species (Bray and Curtis 1957; Curtis 1959, p. 338; Cassidy 2007).

Results from this investigation demonstrate that percent agreement among observers was generally low when identifying oak species from herbarium specimens despite the presence of multiple characters. Most participants correctly identified bur oak, the only representative of section *Quercus*. Despite the presence of multiple, distinct characters, northern red oak was misidentified by more than 20 percent of participants. Distinguishing northern pin oak and black oak can be challenging and undergraduate students did poorly. Agreement improved when either species was accepted as correct; however, percent agreement remained at or below 50 percent for undergraduate students.

The agreement between observers for all specimens was fair. If specimens with intermediate characters were removed from the analysis, agreement improved for all observers, although undergraduate student agreement remained poor. The four graduate students have each had at least one full season in the field identifying oak species. This was reflected in the narrower range of self-perceived competence and in the substantial agreement between the graduate students in categorizing species based on distinct characters. UWSP forestry faculty have various areas of interest, including forest ecology, forest biometry, resource management, urban forestry, economics, and forest soils. Experience identifying trees is variable and is reflected in the broad range of self-perceived competence and the moderate strength of agreement among observers.

While pin oak is planted on the UWSP campus, students and faculty have little experience with pin oak or no experience with scarlet oak. Although, the UW-Madison herbarium (Cameron 2005) does house several collections of scarlet oak, the existence of this species in Wisconsin is in dispute (Rich Hauer, pers. comm., UWSP, Nov. 10, 2010). Students have considerable exposure and experience with northern red oak and northern pin oak. Despite being relatively common in southern and central Wisconsin, black oak is not emphasized in FOR232, thus differences in education and field experience may partially account for the results reported.

Because participants in this study were not chosen randomly from a larger population, these results apply to the participants only and should be generalized with caution. The relatively low level of participation among FOR432 students reflects the requirement that these students attend one of two sessions outside of their assigned class times, while FOR232 students could participate during their normally scheduled class time. Many FOR432 students incorrectly identified several specimens as pin oak. While cautioned to avoid confusing northern pin oak with pin oak it is possible that this error was made.

These results have implications when designing studies that require observers to identify oaks to the species level. This may be particularly relevant for longitudinal studies that rely on the ability of multiple observers, spaced over long periods of time, to make similar identifications. Supervisors of monitoring programs such as the Forest Inventory and Analysis Program, which generate trend data using different staff over long time periods, may need to be cognizant of these findings. Future studies could include forestry professionals and identification of trees in the field. Selecting a random group of individuals from a larger population would allow for less limited generalizations.

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THE MYCORRHIZAL SYSTEM OF *PTEROSPORA ANDROMEDEA* (PINE-DROPS) IN WEST MICHIGAN INFERRED FROM DNA SEQUENCE DATA

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ABSTRACT

Pterospora andromedea is a mycoheterotrophic plant with a disjunct distribution between western and eastern North America and obtains carbon and nutrients indirectly from photosynthetic plants via an ectomycorrhizal fungal bridge. In this study, we used DNA sequence data to determine the organisms involved in the system in West Michigan. Our results suggest that at least two photosynthetic plants (*Tsuga* and *Acer*) are the potential carbon source of the system and that *Pterospora* is specifically associated with an unidentified species of subgenus *Amylopogon* of *Rhizopogon*. Previous studies have shown that seed germination of *Pterospora* relies on chemical cues from the fungus, implying a dominant role of the fungus in the system. Our field observations suggest that repeated branching of *Pterospora* roots increases the mass production of the fungal mycelia and lead us to speculate that *Pterospora* may be a mutualistic partner, not a parasite or exploiter, in the mycorrhizal system.

KEYWORDS: *Pterospora*, nrDNA ITS, *rbc*L, mutualism, mycorrhizal, subgenus *Amylopogon*, *Rhizopogon*.

Pterospora andromedea Torr. (pine-drops) is a mycoheterotrophic plant relying on fungal host for germination, growth, and development (Bakshi 1959). Molecular studies have shown its close relationship with other mycoheterotrophic plants in Ericaceae such as *Monotropa*, *Allotropa*, and *Sarcodes* (Cullings 1994; Kron et al. 2002).

Pine-drops show a disjunct distribution between the eastern and western North America with an extension in the west to northern Mexico (Bakshi 1959). Albeit with a wide distribution, no more than a dozen plants have been seen in one season of any area investigated (Bakshi 1959). This is also true in Michigan where there are 43 occurrences each with a single or small number of individuals, and *Pterospora* has been listed as a State S2 threatened species in Michigan (Higman and Penskar 1999).

Prior to Bakshi (1959) it had not been clear whether *Pterospora* is parasitic on the roots of pine trees (Coulter and Nelson 1909; Piper and Beattie 1914; Hutchinson 1926; Hylander 1939; Fernald 1950) or saprophytic (MacDougal and Lloyd 1899; Jepson 1901; Henderson 1919; Rendle 1925; Copland 1941; Benson 1957). Since there is no chlorophyll in *Pterospora* and its roots have not been found to be organically connected with the roots of photosynthetic vascular

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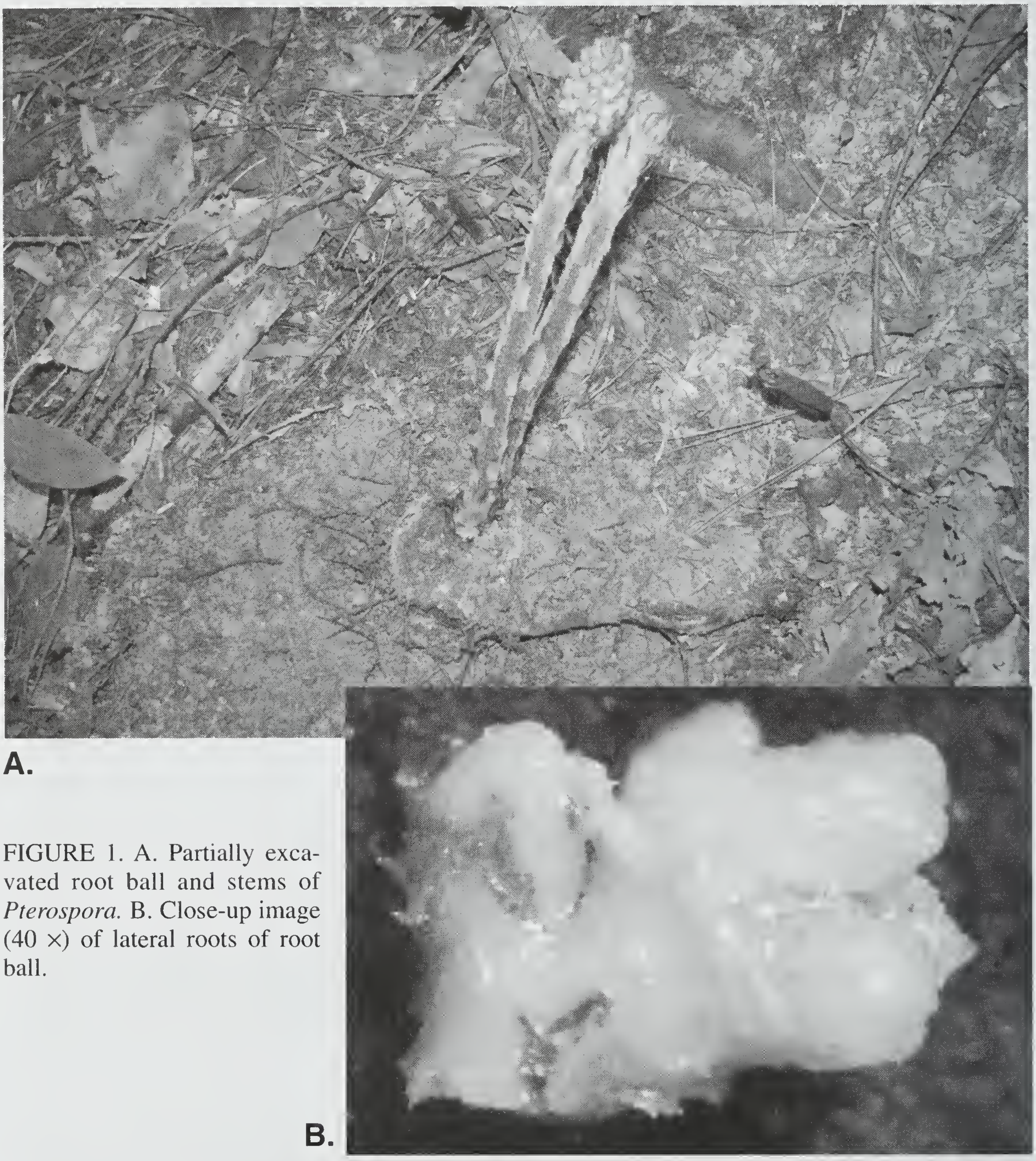

FIGURE 1. A. Partially excavated root ball and stems of *Pterospora.* B. Close-up image (40 ×) of lateral roots of root ball.

plants, Bakshi (1959) concluded that *Pterospora* has to obtain nutrients from fungal mycelia that form a mat completely surrounding the roots of *Pterospora* (Robertson and Robertson 1982; Massicotte et al. 2005). Physiological studies using radioactive elements have shown the movement of materials between parasitic plants (e.g., *Monotropa* and *Sarcodes*) and photosynthetic vascular plants via a fungal bridge (Björkman 1960; Furman 1966; Furman and Trappe 1971; Vreeland et al. 1981). These studies also suggest a more diverse list of host species for the mycorrhizal fungi than has been traditionally speculated. For example, *Acer* as well as *Quercus* may be involved in the mycorrhizal system of *Monotropa* (Furman and Trappe 1971), while *Abies concolor*, *Pinus jeffreyi*, and *Populus tremuloides* have been documented in the mycorrhizal system of *Sarcodes sanguinea* (Vreeland et al. 1981).

Roots of *Pterospora* produce short branches repeatedly generating a globular root ball (Fig. 1), which is penetrated through by, but does not seem to have organic connections with, the roots of photosynthetic vascular plants (Bakshi 1959). It is the fungi that function as a pipeline for material movement between *Pterospora* and photosynthetic vascular plants (Vreeland et al. 1981). Generally, plants have a diverse group of fungal associates to secure the connections (Malloch et al. 1980; Borowicz and Juliano 1991). However, molecular data have demonstrated that *Pterospora* in the western North America is specifically associated with the *Rhizopogon subcaerulensis* group of the genus *Rhizopogon* (Cullings et al. 1996), which is an ectomycorrhizal fungus (Molina and Trappe 1994). However, little information is available for the mycorrhizal system of *Pterospora* in eastern North America since Cullings et al.'s study (1996) did not include any plants from the east and a later study (Bidartondo and Bruns 2001) used only one sample from Québec, Canada. In vitro experiments have suggested that mycorrhizal fungal associations are important for the seed germination of *Pterospora* (Bruns and Read 2000). Therefore, gaining knowledge of the specific association of *Pterospora* and mycorrhizal fungi helps determine factors affecting continual survival of *Pterospora* in Michigan.

Specific objectives in this study were dual: (i) to determine what photosynthetic plants may be involved in the three way system of *Pterospora*, and (ii) to examine whether populations of *Pterospora* in West Michigan are specifically associated with *Rhizopogon* species and whether the associated species are the same as those in the Pacific West.

MATERIALS AND METHODS

Study site. We conducted field collecting in Betts Creek of Mecosta County, MI, in early July of 2011, and found less than 10 individuals of *Pterospora*. To minimize potential damage to the population, we limited our collecting to only two plants: the first with two stems and the other with a single stem. We collected one stem of the first plant as a voucher specimen (*Li, J., J. Corajod, H. Vander Stel, A. Homkes, S. Ross 20117701*, stored at HCHM) and several short roots branching off of the root ball of both plants (Fig. 1). Roots of other vascular plants that were penetrating through the pinedrop root ball were also collected. The roots were washed thoroughly in the lab with distilled water before DNA extraction.

Molecular techniques. The genomic DNA of the root samples was extracted with a Plant DNeasy Mini Kit (Qiagen, CA). Polymerase chain reactions (PCR) were performed to amplify the internal transcribed spacer (ITS) regions of the nrDNA from the root samples of *Pterospora* using universal primers ITS1 and ITS4 (White et al. 1990). Both ITS and *rbc*L genes were amplified from the root samples of other vascular plants using primer pairs ITS1/ITS4 and rbcL5/rbcL3 respectively (Jiao and Li 2007). The PCR products were cleaned up using a RapidTip protocol (Diffinity Genomics, Inc., NY). The *rbc*L gene was sequenced directly from the PCR product using BigDye fluorescent chemistry (Applied Biosystems, CA) and analyzed in a GA 3130 Sequencer (Life Technologies, Carlbad) at Hope College. Because the universal primers for the ITS region may amplify the region from both plants and mycorrhizal fungi, we carried out cloning using the pGEM-T cloning kit (Promega Corporation, WI) to separate sequences from plants and fungi. Clones with inserts were sequenced. All DNA sequences were edited using Sequencher (version 5, Gene Codes Inc., Ann Arbor).

We used the nucleotide Blast function in the NCBI's website to identify sequence identity. All ITS sequences of *Rhizopogon* in the GenBank database were downloaded and aligned with our new sequences using MUSCLE program (Edgar 2004). *Gomphidius*, *Suillus*, and *Truncolumella* were included in the dataset to root the tree, as they may be the closest relative of *Rhizopogon* (Grubisha et al. 2002; Binder and Hibbett 2006). Phylogenetic relationships were estimated using maximum parsimony methods as implemented in MEGA (Tamura et al. 2011) with close-neighbor-exchange (CNI) search on 5000 initial random trees. Nonparametric bootstrapping of 500 replicates was used

TABLE 1. Affinity of sequences from roots of photosynthetic plants (Pp) and *Pterospora* (Pt) as determined by blasting analysis in the GenBank. Numbers 1 and 2 after Pp and Pt indicate plants 1 and 2, respectively, and the second numbers represent root samples from all around the root ball of *Pterospora*. Numbers in parentheses indicate number of clones sequenced. NA, no amplifications tried.

Sample	*rbcL*	ITS
Pp 1A	*Tsuga* (hemlock)	NA
Pp 2.1 (4)	*Acer saccharum* (sugar maple)	*Agrocybe* (*Basidiomycetes*), *Sordariomycetes*, *Rhizopogon*, *Acer saccharum*
Pt 1.2 (3)	NA	*Rhizopogon*
Pt 1.3 (3)	NA	*Rhizopogon*
Pt 1.8 (2)	NA	*Rhizopogon* *Pterospora*
Pt 1.10 (3)	NA	*Rhizopogon*
Pt 1.11 (1)	NA	*Rhizopogon*
Pt 2.2 (4)	NA	*Rhizopogon*
Pt 2.4 (1)	NA	*Rhizopogon*
Pt 2.6 (5)	NA	*Rhizopogon*

to measure relative support for individual clades (Felsenstein 1985) and the tree search options were as in the MP analysis except for the initial random trees set to 100.

RESULTS

Genomic DNA was successfully extracted from eight root samples of *Pterospora* and two root samples of other vascular plants. BLAST analysis of the plastid *rbc*L gene from the roots of other vascular plants suggested that they were from either *Tsuga* or *Acer*. A root sample of other vascular plants contained ITS sequences of *Acer saccharum*, *Agrocybe*, *Sordariomycetes*, and *Rhizopogon* (Table 1).

The ITS sequences from all *Pterospora* root samples were found to be from *Rhizopogon* except for one that contained both *Rhizopogon* and *Pterospora* (Table 1).

There were 105 sequences and 996 sites in the aligned ITS data set, 420 of which were parsimony informative. Phylogenetic analyses generated 67 most parsimonious trees of 2108 steps, a consistency index of 0.59, and a retention index of 0.77. Sequences from the mycorrhizal fungi of both individuals of *Pterospora* formed a well-supported clade (bootstrap support = 93%), which was in the clade containing species of subgenus *Amylopogon sensu* Grubisha (bs=97%), but its relationship with other species was not resolved (Fig. 2). All sequences are from *Rhizopogon* samples in the Pacific West except for Queb3000, which is an environmental sample from Québec, Canada.

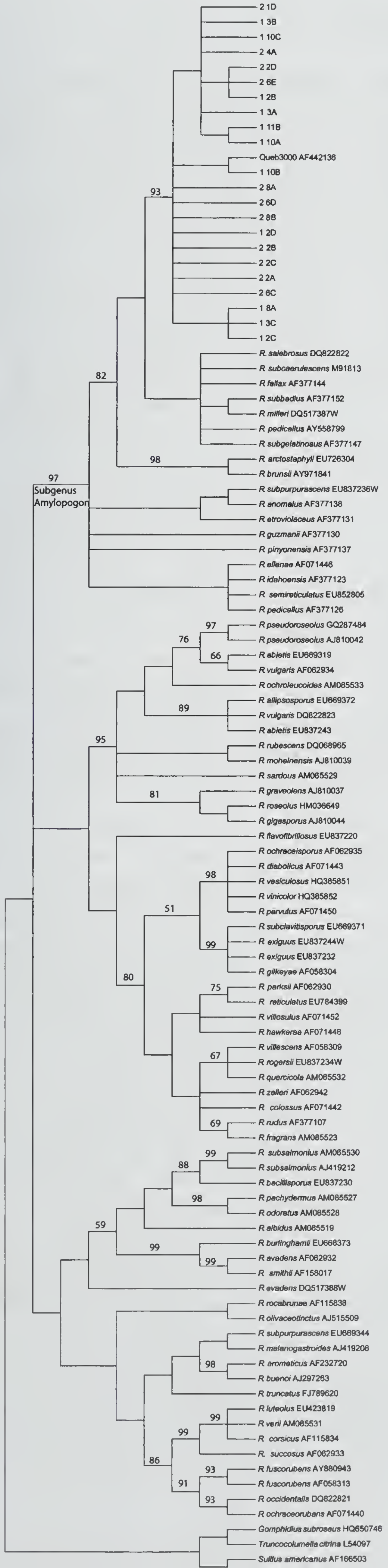
2 1D
1 3B
1 10C
2 4A
2 2D
2 6E
1 2B
1 3A
1 11B
1 10A
Queb3000 AF442136
1 10B
93
2 8A
2 6D
2 8B
1 2D
2 2B
2 2C
2 2A
2 6C
1 8A
1 3C
1 2C
R. salebrosus DQ822822
R subcaerulescens M91813
82
R fallax AF377144
R subbadius AF377152
R milleri DQ517387W
R pedicellus AY558799
R subgelatinosus AF377147
98
R arctostaphyli EU726304
R brunsii AY971841
97
Subgenus
Amylopogon
R subpurpurascens EU837236W
R anomalus AF377138
R atroviolaceus AF377131
R guzmanii AF377130
R pinyonensis AF377137
R ellenae AF071446
R idahoensis AF377123
R semireticulatus EU852805
R pedicellus AF377126
97
R pseudoroseolus GQ287484
76
R pseudoroseolus AJ810042
66
R abietis EU669319
R vulgaris AF062934
R ochroleucoides AM085533
R ellipsosporus EU669372
89
R vulgaris DQ822823
R abietis EU837243
95
R rubescens DQ068965
R mohelnensis AJ810039
R sardous AM065529
81
R graveolens AJ810037
R roseolus HM036649
R gigasporus AJ810044
R flavofibrillosus EU837220
R ochraceisporus AF062935
R diabolicus AF071443
98
R vesiculosus HQ385851
R vinicolor HQ385852
51
R parvulus AF071450
R subclavitisporus EU669371
99
R exiguus EU837244W
R exiguus EU837232
R gilkeyae AF058304
80
75
R parksii AF062930
R reticulatus EU784399
R villosulus AF071452
R hawkerae AF071448
R villescens AF058309
67
R rogersii EU837234W
R quercicola AM065532
R zelleri AF062942
R colossus AF071442
69
R rudus AF377107
R fragrans AM085523
99
R subsalmonius AM065530
88
R subsalmonius AJ419212
R bacillisporus EU837230
98
R pachydermus AM085527
R odoratus AM085528
59
R albidus AM085519
R burlinghamii EU668373
99
R evadens AF062932
99
R smithii AF158017
R evadens DQ517388W
R rocabrunae AF115838
R olivaceotinctus AJ515509
R subpurpurascens EU669344
R melanogastroides AJ419208
98
R aromaticus AF232720
R buenoi AJ297263
R truncatus FJ789620
R luteolus EU423819
99
R verii AM085531
99
R corsicus AF115834
R. succosus AF062933
86
93
R fuscorubens AY880943
91
R fuscorubens AF058313
93
R occidentalis DQ822821
R ochraceorubens AF071440
Gomphidius subroseus HQ650746
Truncocolumella citrina L54097
Suillus americanus AF166503

FIGURE 2. Strict consensus of 67 most parsimonious trees produced from ITS sequences of *Rhizopogon* fungi and close relatives (CI=0.59, RI=0.77). Numbers at branches are bootstrap percentages of 500 replicates greater than 50%.

DISCUSSION

Several photosynthetic plants may be the ultimate source of carbon for the mycorrhizal system of *Pterospora andromedea.* The plant grows in woods containing conifers (e.g. pines, hemlock, spruce) and broad-leaved deciduous trees (e.g., aspen, maple, and birch) (Higman and Penskar 1999). Although no study has been done on nutritional movement between photosynthetic plants and *Pterospora*, results from other mycoheterotropic systems of Ericaceae (Björkman 1960; Furman 1966; Furman and Trappe 1971; Vreeland et al. 1981) indicate that several photosynthetic plants are involved in the system providing carbon source, and imply that the mycorrhizal system of *Pterospora* may also have more than one photosynthetic plant participating. Our results support the implication; DNA sequences we obtained from roots penetrating root ball of *Pterospora* show close affinity with those of *Tsuga canadensis* and *Acer saccharum*, both naturally occurring together with *Pterospora.* Interestingly, we did not get sequences from pines, another possible carbon source of *Pterospora* hinted by the common name of the plant. This is probably due to our limited sampling of pine-drops in the population.

Like the populations of *Pterospora* in the Pacific West (Cullings et al. 1996; Bidartondo and Bruns 2001; Bidartondo and Bruns 2002), *Pterospora* in West Michigan shows an extreme mycorrhizal specificity with subgenus *Amylopogon* of *Rhizopogon.* Mycorrhizal mutualistic association is nearly universal in terrestrial plant systems and has important impact on ecology and evolution of organisms involved (Malloch et al. 1980; Molina and Trappe 1994). In general, mutualistic associations of fungi and plants are nonspecific (Hadley 1970): one plant with many fungal associates and vice versa. However, when present, the specific association is generally one-sided with one plant having multiple fungal associates (Malloch et al. 1980; Borowicz and Juliano 1991). Monotropes are a rare example of the evolution of mycorrhizal associations to an extreme specificity; all populations of *Pterospora* in the Pacific West are associated only with species of subgenus *Amylopogon* in *Rhizopogon* (Cullings et al. 1996). In the root of *Acer saccharum*, a potential carbon source of *Pterospora*, there are several fungal associates including *Agrocybe*, *Sordariomycetes*, and *Rhizopogon.* However, only subgenus *Amylopogon* of *Rhizopogon* is found in the root samples of *Pterospora* (Table 1). Interestingly, while all sequences of *Rhizopogon* from the two *Pterospora* plants form a well-supported clade with an existing sequence in the GenBank (Québec, Canada) (Fig. 2), they differ from other species of subgenus *Amylopogon* from the west. Unfortunately, subgenus *Amylopogon* (ca. 16 spp. in North America) has rarely been collected from the east (Smith 1951, 1966, 1968; Smith and Zeller 1966). Therefore, it is unclear whether or not the species associated with *Pterospora* in West Michigan and Québec represents a new species within subgenus *Amylopogon.*

We did not find direct connections of *Pterospora* with roots of photosynthetic plants, supporting the conclusion that *Pterospora* obtains carbon from the mycelia of *Rhizopogon* (Bakshi 1959). *Pterospora* has been considered as a parasite (Bakshi 1959) or an exploiter of fungi (Bidartondo and Bruns 2002) because it is not obvious that *Pterospora* may be beneficial to the mycorrhizal fungi. *Pterospora* produces thousands of winged seeds per plant (Bakshi 1959) and should therefore have ample opportunities to form associations with numerous fungi in the soil. Nonetheless, the association of *Pterospora* with subgenus *Amylopogon* is extremely specific (Bidardonto and Bruns 2001, 2002; Fig. 1). Seeds of *Pterospora* do not contain fungal hyphae and their germination has to be stimulated by chemical cues released from the fungi (Bruns and Read 2000), indicating that fungi might be the dominant player in the unique association. Fungal mycelia form a mantle enclosing roots of *Pterospora* and may stimulate the frequent branching of the roots to form a root ball. We noted in the field that the root ball apparently increases the production of fungal mass, which may be advantageous for fungal growth, development, and reproduction. Therefore, *Pterospora* may not be a fungal exploiter or parasite, but a partner of a mutualistic system.

The survival of *Pterospora* depends on the specific species of *Rhizopogon* and its symbiotic relationship with photosynthetic plants. Therefore, any protection plan for the threatened species in Michigan (Higman and Penskar 1999) should consider the protection of the entire system including the photosynthetic plants and false truffles as well as pine-drops.

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We thank the Michigan Botanical Foundation for supporting the project, Steve Ross for help in the field, Department of Natural Resources of Michigan for granting collection permit, Mike Penskar for providing locality information of *Pterospora* in West Michigan, and Dr. Garrett and anonymous reviewers for their constructive comments on the manuscript.

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IN MEMORIAM – DR. RICHARD MCNEILL

Dr. Richard McNeill

Seney National Wildlife Refuge would like to recognize the work of Dr. Richard "Dick" McNeill. Dick McNeill passed away on 23 November, 2009 at the age of 83. He volunteered at the Seney National Wildlife Refuge (Seney NWR or Refuge) for nearly 16 years. These efforts produced a well-managed, professional quality, state recognized herbarium that has been, and will continue to be, a valuable asset to Refuge staff and colleagues. Seney NWR is blessed to have this herbarium for use as reference material and to help guide habitat management. The Refuge was established, in 1935, under the Migratory Bird Conservation Act; it encompasses over 95,000 acres and provides habitat for a diversity of wildlife species. Many of the vegetation communities found at the Refuge are resources of conservation and restoration priority as they are poorly represented elsewhere in the state or nation.

Four years after the Refuge was established, the herbarium collection was started. In the early 1990's a cardboard box containing these herbarium specimens was discovered and "rescued" by the administrative technician. Interest in maintaining the collection waned until the mid-1990s when Dick McNeill arrived as a volunteer and became an eager herbarium trustee.

Dick McNeill grew up in Detroit, served during World War II, and earned his Doctorate from the University of Michigan in Ann Arbor. Dick's academic career started by teaching in Arcadia, followed by teaching seventh grade and eventually middle school and high school biology in Traverse City. After earning his Doctorate (1971), Dick taught biology, ecology, wildlife conservation, and environmental health at Ferris State University in Big Rapids. Upon retiring in 1983, Dick and his wife Elsia bought a house in Grand Marais, Michigan, about 30 miles north of Seney National Wildlife Refuge, where they spent many summers. In 1992, Dick and Elsia moved to Grand Marais full time and sought out volunteer opportunities at the Refuge soon after.

Dick brought his passion for science and teaching with him to the Refuge. He shared his knowledge and excitement with hundreds of visitors each year and had an influence on dozens of interns. Although Dick's interests varied, he had a passion for plants and a desire to do more at the Refuge. He became involved with the Refuge's herbarium collection, and for more than a decade made significant contributions to its development and organization.

Dick systematically arranged all of the Refuge's existing specimens according to *Gray's Manual of Botany* and *Michigan Flora* and initiated the preparation of a digital herbarium species list allowing information to be easily retrieved. He personally collected, mounted, identified, and labeled over 200 of the specimens currently in the herbarium. When help with identification was needed, Dick corresponded with nationally recognized systematic botanist, Dr. Edward Voss (University of Michigan), to get the answers. During all this activity, Dick continued to teach young folks by regularly instructing student interns on properly preparing botanical specimens and working with them to create a usable herbarium exhibit for the Visitor Center. During his collection forays, Dick often collected and transplanted Refuge plants to the Visitor Center to help educate visitors about local flora and the benefits of landscaping with native plants.

Dick's knowledge and desire to teach affected many Refuge staff, interns, and visitors. We miss his presence, appreciate his volunteer efforts, and recognize his contribution to the U.S. Fish and Wildlife Service, the National Wildlife Refuge System and the field of botany in the State of Michigan.

J. Wycoff-McDonough

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On the cover: *Pterospora andromedea* in Mecosta County, MI.
Photo taken by Jianhua Li July 7, 2011.

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TANACETUM BIPINNATUM GERMINATION AND COMPETITIVE INTERACTION WITH CENTAUREA STOEBE SEEDLINGS

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ABSTRACT

Tanacetum bipinnatum (Asteraceae) is limited in distribution in the Great Lakes region to sand dune ecosystems and is threatened in Michigan and endangered in Wisconsin. Germination and establishment interruptions for *T. bipinnatum* may add to the limitations in distribution and be exacerbated by the presence of *Centaurea stoebe* (Asteraceae), which has invaded many different ecosystems around the Great Lakes region, including dunes. I conducted a germination experiment with *T. bipinnatum* seeds undergoing variable cold storage lengths (0–5 months) or germinating in the presence or absence of light. Also, I conducted a competition experiment with establishing *T. bipinnatum* and *C. stoebe* individuals. With light present for germination, 1 and 2 month cold storage periods had 10% germination. Germination was not independent of cold storage in dark treatments, with only 5% of seeds germinating in controls without cold storage. In competition with *C. stoebe*, *T. bipinnatum* had reduced above-ground biomass and root length compared to *T. bipinnatum* grown with a conspecific and individually. Below-ground biomass for *T. bipinnatum* was significantly reduced in competition with *C. stoebe* compared to when it was grown individually. The only alteration in growth for *C. stoebe* was in below-ground biomass, which was greater in competition with *T. bipinnatum*. Limited seed germination and competition during establishment may explain why *T. bipinnatum* occurs at lower densities in areas invaded by *C. stoebe*. Further research is needed to quantify survival of mature *T. bipinnatum* beyond the initial establishment in competition with *C. stoebe*.

KEYWORDS: invasive species, threatened, Lake Huron tansy, spotted knapweed

INTRODUCTION

The post-dispersal establishment of seedlings is essential to the continuation of a plant population (Harper et al. 1965; Eriksson and Ehrlén 1992). Interruption of establishment often leads to reductions in densities, modification of community physical structure, or can lead to alteration of successional patterns (Denslow 1980; Pyke and Archer 1991; Luzuriaga and Escudero 2009). Theoretical extreme ends of the continuum of plant population dynamics are those that are limited by the availability of what Harper et al. (1961) defined as "safe sites" in the presence of abundant seed and those that are limited by the availability of seed in the presence of abundant "safe sites" (Duncan et al. 2009). Somewhere along the continuum, plant population dynamics are most likely driven by combinations of site and seed availability.

Tanacetum bipinnatum (Lake Huron tansy, Asteraceae, =*T. huronense*) is a wide ranging species and occurs in several Canadian provinces and northern US states from Maine to Alaska, with those occurrences being sparse (Canadian Museum of Nature Herbarium 2010). Within the Great Lakes region it is limited in distribution to sand dune ecosystems and as a consequence is listed as a threatened species in Michigan and an endangered species in Wisconsin (Voss 1996; Wisconsin Department of Natural Resources 2009; Michigan State University Extension 2010). Nichols (1934) identified a dramatic improvement in *T. bipinnatum* seed germination with the application of cold storage treatments; 59% germination following 71 days in cold storage and 12% germination without cold storage. Adapting to burial of seed by sand accretion in active dune systems, many plants have improved germination and establishment rates when light is absent (Maun and Lapierre 1986; Maun 1994). Chen and Maun (1999) demonstrated the importance of seed burial for *Cirsium pitcheri* [Torr. ex Eaton] Torr. & A. Gray, another threatened plant species in sand dunes.

Centaurea stoebe (spotted knapweed, Asteraceae, =*C. maculosa* and =*C. biebersteinii*) is a common, aggressive invader of those same dune ecosystems, as well as non-dune ecosystems, and is native to Europe and Asia (Watson and Renney 1974; Marshall et al. 2008). Within Grand Sable Dunes, Pictured Rocks National Lakeshore, MI, areas invaded by *C. stoebe* have significantly reduced native plant diversity and increased exotic plant diversity in comparison with areas without this exotic (Marshall et al. 2008). The area invaded by *C. stoebe* and its density has increased in Grand Sable Dunes over the past 35 years from being limited to roadsides, to being rare in the dunes, to finally becoming a major invader (Read 1975; Bach 1978; Marshall et al. 2008). Also, areas with *C. stoebe* in Grand Sable Dunes had 3 times less percent cover of *T. bipinnatum* as compared to areas without *C. stoebe* (Marshall et al. 2008). Latsch (2011) surveyed a similar area of Grand Sable Dunes and did not encounter *T. bipinnatum* in areas invaded by *C. stoebe*. The influence of *C. stoebe* competition on results presented by Marshall et al. (2008) and Latsch (2011) is not clear. There is evidence that *C. stoebe* competition does reduce the growth of some neighboring native plants species (Ridenour and Callaway 2001). However, *Ammophila breviligulata* Fernald, a native dune grass, reduced *C. stoebe* growth in competition (Emery and Rudgers 2012). Exotic plant management targeting *C. stoebe* has occurred in Grand Sable Dunes. However, the availability of funding has limited the size and frequency of these programs (B. Leutscher, National Park Service, per. comm.).

The objectives of this study were to identify the importance of cold storage and light on the germination success of *T. bipinnatum* seed and to quantify the competitive interactions between *T. bipinnatum* and *C. stoebe* seedlings.

MATERIALS AND METHODS

Seed collection and storage

I collected *T. bipinnatum* seed from 5 plants in Grand Sable Dunes, Pictured Rocks National Lakeshore, MI (46° 39′ 27.5″ N, 86° 1′ 56.3″ W). I also collected *C. stoebe* seed from a road-side population adjacent to Pictured Rocks National Lakeshore. All seeds were collected 12 September 2010. Seeds were separated from plants and stored for 3 months at ambient laboratory temperature (approximately 24°C).

Germination study design

Tanacetum bipinnatum seeds were pooled and randomly placed into cold storage treatments (1, 2, 3, 4 and 5 month storage) wrapped in moist paper towels in polyethylene bags at 5°C, as well as a control with no cold storage. I initiated all cold storage treatments simultaneously and seeds in each treatment were removed for germination following the requisite storage period. Following treatment, I initiated 4 replicates of each treatment with approximately 3 ml of distilled water applied to the filter paper (Whatman No. 42), 5 equally spaced seeds were placed in each Petri dish (100 mm x 15 mm), dishes were sealed with Parafilm (Pechiney Plastic Packaging, Wenasha, WI), and seeds were allowed to germinate with 16:8 light:dark cycle at 25°C. Control seeds without cold storage were placed in Petri dishes for germination when other seeds entered cold storage. I also applied light absent treatments (dark) to 4 additional replicates of each of the 1 month and control cold storage treatments. Replicate Petri dishes in the dark treatments were sandwiched between two pieces of corrugated cardboard (3 mm thick) and the edges were sealed with duct tape.

Competition study design

The remainder of pooled *T. bipinnatum* seeds, as well as *C. stoebe* seeds, were wrapped in moist paper towels, and stored in polyethylene bags at 5°C for 2 months. Seeds were germinated on moist filter paper in Petri dishes following cold storage. Once the radicle was present, seedlings were transplanted to cylindrical planting cells (3.8 cm diameter × 14 cm, BioQuip Products, Rancho Dominguez, CA). Treatments, with 10 replicates each, included *T. bipinnatum* single grown individuals, grown in competition with another *T. bipinnatum* individual, and grown in competition with a single *C. stoebe* individual, as well as *C. stoebe* single grown individuals. Plants were watered as needed (every 1–3 days) and grown in clean play sand with 16:8 light:dark cycle at 25°C. Granular fertilizer (12% N, 4% P, 8% K) was applied to the surface of each planting cell 2 weeks following transplantation. After 3 months of growth, seedlings were harvested, numbers of leaves were counted, and root length was measured. Plants were dried at 50°C to a constant weight and above- and below-ground biomass was measured. Root:shoot ratio was calculated using biomass.

Data analysis

Fisher's exact tests were used to test the hypotheses that germination of *T. bipinnatum* was independent of cold storage and light. One-way analysis of variance (ANOVA) with Tukey's HSD post-hoc test was used to test for differences in leaf counts, root length, above- and below-ground biomass, and root:shoot ratio between *T. bipinnatum* individuals grown in and out of competition. T-tests were used to test for differences in leaf counts, root length, above- and below-ground biomass, and root:shoot ratio between *C. stoebe* individuals grown in and out of competition.

RESULTS

A total of 16 *T. bipinnatum* seeds germinated (10.0%) across all treatments taking a mean of 3.4 days (SD 1.0) to germinate. There was a reduction in the percent of seeds germinating with each increase in cold storage length (Figure 1). Also, darkness drastically increased number of germinating seeds after 1 month of cold storage (Figure 1). While the percent of seeds germinating appeared different, germination was independent of light regardless of cold storage ($P = 0.123$). Also, germination was independent of cold storage regardless of light treatment ($P = 0.769$). When analyzed separately, germination was independent of cold storage when light was present ($P = 0.171$), but was not independent of cold storage when light was absent ($P = 0.046$). Seed germination was not isolated to single dishes in treatments with greater than 5% germination (1 seed).

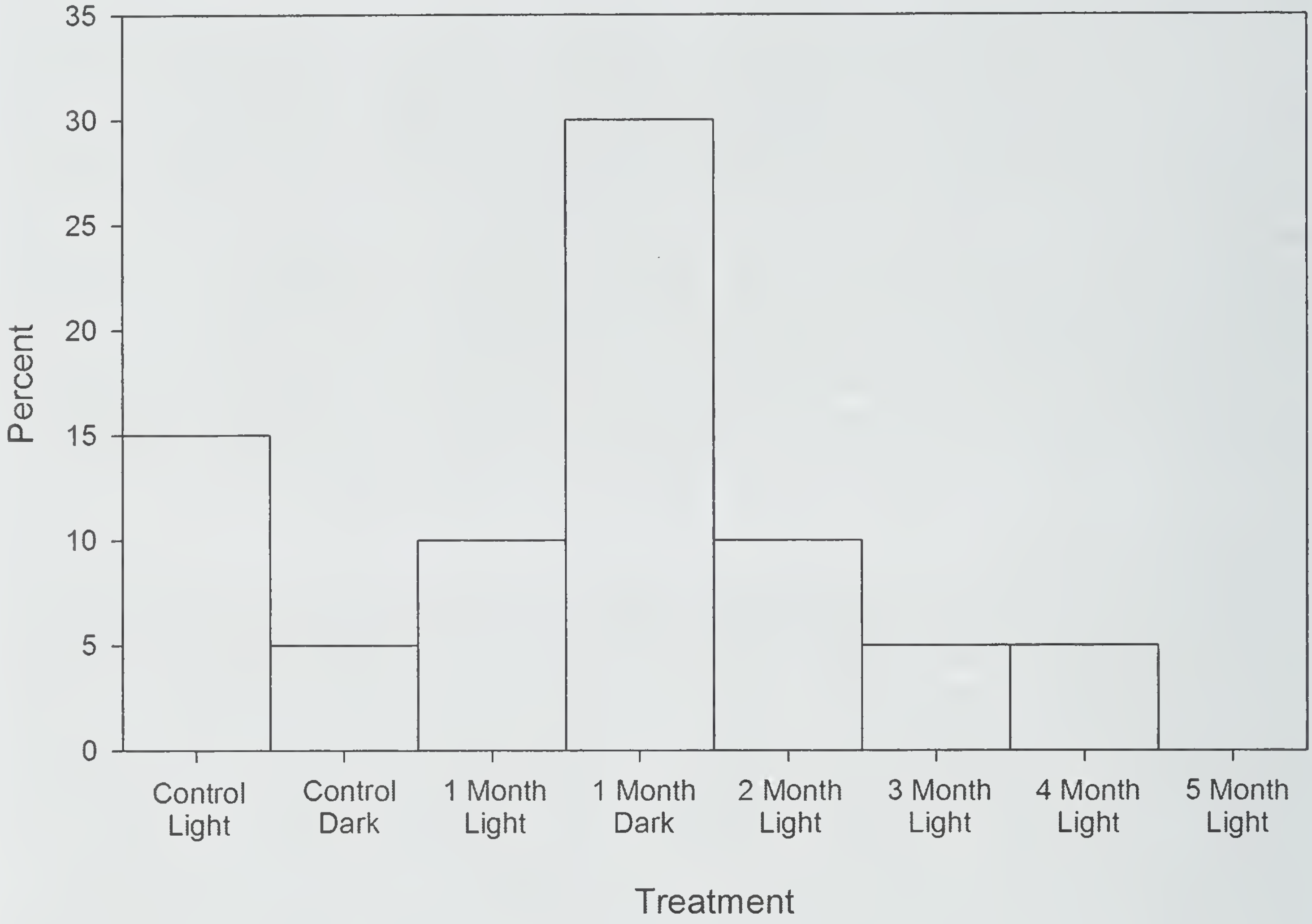

FIGURE 1. Percent of *Tanacetum bipinnatum* seeds germinating after 5 °C cold storage treatments (1–5 months), in light and dark treatments, and controls without cold storage.

Tanacetum bipinnatum leaf count was significantly greater when grown in conspecific competition than in competition with *C. stoebe*; however, these values did not differ from the single grown *T. bipinnatum* individual (Table 1). In competition with *C. stoebe*, *T. bipinnatum* had significantly reduced above-ground biomass compared to both single grown and conspecific competition. A similar response occurred for root length. Below-ground biomass differed between the single grown *T. bipinnatum* and in competition with *C. stoebe*.

TABLE 1. Mean leaf number, above- and below-ground biomass, root length, and root:shoot ratio (SE) for *Tanacetum bipinnatum* grown in competition with a conspecific (TB-TB), in competition with *Centaurea stoebe* (TB-CS), and controls as single individuals (TB). Unique letters indicate significant difference between treatments using analysis of variance with Tukey's HSD post-hoc test.

Biomass (mg)					
Treatment	Leaf Count	Above-Ground	Below-Ground	Root Length (mm)	Root:Shoot
TB-TB	5.3 (0.2) a	16.77 (1.87) a	3.86 (0.67) ab	148.3 (11.6) a	0.24 (0.04) a
TB-CS	4.2 (0.1) b	7.15 (0.77) b	2.30 (0.47) b	64.7 (13.5) b	0.34 (0.07) a
TB	4.7 (0.3) ab	18.92 (2.62) a	5.16 (1.03) a	129.0 (11.9) a	0.28 (0.5) a
$F_{2,27}$	6.94	10.78	3.53	10.55	0.85
P	0.004	< 0.001	0.043	< 0.001	0.438

Conspecific competition reduced *T. bipinnatum* below-ground biomass; however, it was not significantly different from the other two treatments. Although above- and below-ground biomass was altered by competition with *C. stoebe*, the root:shoot ratio did not differ between treatments (Table 1). Adding *T. bipinnatum* competition to *C. stoebe* did not significantly alter any of the growth variables measured. The exception in *C. stoebe* growth was below-ground biomass, which was significantly greater in competition with *T. bipinnatum* than without (24.72 [SE 4.31] vs. 16.68 [SE 1.40], $t = 1.77$, df = 18, P = 0.047).

DISCUSSION

The overall germination rate of *T. bipinnatum* seeds the experiment presented here was relatively low compared to other *Tanacetum* species, which had approximately 50–96% germination (Mitchell 1926; Jacobs 2008; Li et al. 2011), as well as previous reports for *T. bipinnatum* rates (Nichols 1934). While cold storage did not appear to improve germination rates, applying a darkness treatment dramatically improved *T. bipinnatum* germination rates. This is likely related to sand accretion within dune ecosystems, allowing seedlings to establish in an environment with active dunes. *Tanacetum bipinnatum* is typically found along both active and well stabilized dunes, as described by Voss (1996), in areas with sand accretion that would likely bury seeds. The moderate increase in control seeds germinating compared to those with cold storage or dark control treatments may be related to pre-winter germination, in that a sub-set of seed may be able to germinate without winter temperatures or burial in sand. Those seeds germinating without exposure to cold temperatures would have a lower likelihood of being buried by sand and may have light requirements in order to germinate. Survival of those seedlings establishing prior to winter is not known, but survivorship of *T. bipinnatum* seedlings may be variable related to the timing of germination, as with other dune plant species (Maun 1994).

Previously, Marshall et al. (2008) found *T. bipinnatum* percent cover was 3-times greater in areas without compared to areas with *C. stoebe*. In addition, Latsch (2011) did not encounter any *T. bipinnatum* individuals in areas invaded by *C. stoebe*. The results presented here demonstrate that *T. bipinnatum* seedlings in the presence of *C. stoebe* had reduced above- and below-ground biomass compared to plants grown individually. Even *T. bipinnatum* grown in competition with a conspecific had greater leaf count, above-ground biomass, and longer roots, suggesting that growth reductions in competition with *C. stoebe* are not simply the result of another plant present. Competition with *C. stoebe* can cause significant reductions in the numbers and biomass accumulation in other plant species (Callaway et al 1999; Ridenour and Callaway 2001). Mechanisms of these growth reductions through competition may not be clear; however, in competition with *T. bipinnatum*, *C. stoebe* accumulated significantly more below-ground biomass than when grown individually. This additional root biomass may have resulted in increased surface area for water and nutrient absorption. The allelopathic effect of (±)-catechin produced by living *C. stoebe* roots has been suggested as having variable influence on neighboring plants (He et al. 2009). Allelopathy may be one explanation for the lower biomass accumulation of *T. bipinnatum* in competition with *C. stoebe.*

Seed from *T. bipinnatum* collected at Pictured Rocks National Lakeshore had relatively low germination rates, limiting the number of viable seeds available for population expansion and survival within the Grand Sable Dunes. Those seeds that are able to germinate may suffer as seedlings establishing under competition with *C. stoebe*. Potentially low germination rates in combination with increasing competition by expanding populations of *C. stoebe* within dune ecosystems may further limit the distribution of *T. bipinnatum* within the Great Lakes region and may explain why previous studies in the Grand Sable Dunes found *T. bipinnatum* absent or with reduced percent cover. An additional factor potentially affecting population expansion is related to pollination success. Other *Tanacetum* species, such as *T. vulgare* (=*Chrysanthemum vulgare*), have a strong indication of self-incompatibility (Lokki et al. 1973). Therefore, low density *T. bipinnatum* populations, like those found in Grand Sable Dunes, may experience problems related to pollinator success. Additional research is needed to identify mortality and growth rates of maturing *T. bipinnatum* past the first three months of establishment in competition with *C. stoebe* and other invasive plants.

ACKNOWLEDGEMENTS

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THE USE OF FLORISTIC QUALITY ASSESSMENT AS A TOOL FOR MONITORING WETLAND MITIGATIONS IN MICHIGAN

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ABSTRACT

Since the concept of creating and restoring wetlands as mitigation for impacted wetlands is still relatively new, the most effective method of assessing vegetation quality in mitigation wetlands has yet to be determined. United States Army Corps of Engineers permit requirements for wetland mitigations include periodic vegetation sampling, and Floristic Quality Assessment (FQA) has been recommended as a method of monitoring wetland quality. The goal of this study was to validate the use of FQA as a tool in monitoring wetland mitigations by comparing FQA performance against *a priori* Best Professional Judgement (BPJ) and traditional diversity indices. We also compared the variation in results from three regional FQA databases as well as the effect of quadrat size. A total of 21 wetland mitigation sites located throughout the Lower Peninsula of Michigan were included in this study. The sites exhibited a wide range of quality according to both *a priori* Best Professional Judgement (BPJ) and FQA data analysis. Based on the Michigan FQA database, BPJ exhibited strong correlation with standard FQA metrics, mean C ($r = 0.83$) and Floristic Quality Index (FQI; $r = 0.70$). The correlation was marginally lower when metrics were based upon the Indiana FQA database and smaller (0.25 m^2) quadrats. In contrast, mean wetness and total species had low correlations ($r = 0.45$ and $r = 0.19$) with BPJ. Shannon's Diversity Index, Simpson's Diversity Index, and species evenness were poorly correlated with FQI ($r < 0.45$) and very poorly with mean C ($r < 0.20$). FQA results from our 21 sites were very similar to those reported for ten other mitigation sites in northern Indiana. FQA results from all mitigation sites were lower than those seen in several natural wetlands. We conclude that wetland mitigations may not fully replace the vegetative functions of natural wetlands in the short term, but in terms of monitoring, FQA may be one tool used for assessing mitigation wetland quality.

KEYWORDS: wetland monitoring, FQA, BPJ, diversity indices

INTRODUCTION

Human development of the land has resulted in extensive loss of natural wetlands (USACE 2008). As a result, nearly 50% of the natural wetlands in the United States (Dahl 1990) and over 70% in Michigan have been drained or filled (Comer et al. 1993a, 1993b, 1996). The “no net loss” of wetland policy, implemented in 1989 by United States Environmental Protection Agency, seeks to forestall this loss by requiring that if a wetland is destroyed for any reason, another one must be created sufficient to keep wetland area constant (Streever 1999). The ultimate goal of these wetland mitigations is to replace as fully as possible the functions and public benefits of lost wetlands (National Research Council 2000, USACE 2008).

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Section 404 of the Clean Water Act and subsequent clarifying Rules describe the requirements involved in the permitting scheme for wetland mitigation. Based upon Section 404, the United States Army Corps of Engineers (USACE) requires a periodic monitoring of mitigation wetlands to assess ecological performance in an objective and verifiable way (see Federal Register 73(70):19594-19705 dated April 10, 2008). In practice, the parameters involved in monitoring vary across USACE Districts, but vegetation surveys are a necessary component. Increasingly, Districts require the use of Floristic Quality Assessment (FQA) to monitor wetland mitigations over a minimum of five-years to complete the permitting process (Adamus et al. 1987, Streever 1999, USACE 2008, 2009). In addition, they require the demonstration of high vegetative cover by native, non-invasive hydrophytes (USACE 2008, 2009), especially perennials (USACE 2009), and may require the reporting of familiar ecological diversity indices (USACE 2008).

FQA was originally developed as a standard method for natural area assessment in the Chicago region (Swink and Wilhelm 1979). In its current form, Swink and Wilhelm (1994) promote its use in identifying natural areas, facilitating comparisons between sites, long-term monitoring of remnant natural quality, and monitoring of habitat restoration.

A core concept in FQA is the “coefficient of conservatism” (C), a value from 0 to 10 that is assigned to each native species (Swink and Wilhelm 1994). The C values for each species represents an estimate of species fidelity to a presettlement community with minimal anthropogenic degradation. C values are applied at a regional or state level since the behavior of plant populations can be different throughout the range of the species. The further a species is from a region for which C values have been developed, the more likely it is that the values will not reflect the local conservatism of the species. Therefore, it is recommended that a specific database be tailored for the state or the particular region in which the FQA will be used (Swink and Wilhelm 1994).

The performance of FQA has been reported for a variety of habitats: grasslands (Jog 2006), old fields (Spyreas et al. 2012), prairies (McClain and Ebinger 2002, Bowles and Jones 2006, Taft et al. 2006, McIndoe et al. 2008), streambanks (Bowers and Boutin 2008), woodlands (Francis et al. 2000, Doucet-Beer et al. 2007), and wetlands (Oldham et al. 1995, Lopez and Fennessey 2002, Mushet et al. 2002, Cohen et al. 2004, Herman 2005, Jones 2005, Matthews et al. 2005, Miller and Wardrop 2006, Bourdaghs et al. 2006, Nichols et al. 2006). A limited number of published studies examine the use of FQA on wetland mitigations (Elifritz and Fennessy 1999, Balcombe et al. 2005, Herman 2005).

The purpose of this study was to validate the performance of FQA in assessing quality of mitigation wetlands, especially in the context of current monitoring requirements by USACE (2008, 2009). In particular, FQA metrics were compared to a scale of quality based upon *a priori* Best Professional Judgment (BPJ) in order to test the response to a range of mitigation qualities. The metrics tested included species richness, mean C, FQI, and mean wetness (Swink and Wilhelm 1994, Wilhelm and Masters 1999). In addition, this study examined the robustness of FQA results by varying quadrat size (1.0 m^2 versus 0.25 m^2 quadrats) and FQA databases (Michigan versus Indiana and Chicago). Finally, several ecological indices frequently used to measure community structure in mitigation wetlands—Shannon's Diversity Index, Simpson's Diversity Index, and species evenness—were compared to FQA metrics.

METHODS

Study Sites

A total of 21 wetland mitigation sites under the jurisdiction of the Michigan Department of Transportation (MDOT) were sampled (Appendix 1; Figures 1–4). The majority of them were located adjacent to or near highways in the greater Grand Rapids and Lansing areas with additional sites near Benton Harbor and Cadillac. The sites varied in age (3–12 years old) and size (1.6–21 hectares).

Around the year 2002, MDOT instituted a design change to future mitigations due to a realization that portions of older sites (greater than 5 years at time of sampling) were failing to reach desired performance. The previous design employed a bowl-shaped wetland. Because of the steep gradient of the side slopes the wetland typically failed to establish wetland characteristics uniformly. After the design change, the mitigation wetlands were constructed with a very small gradient on the sides. The Weaver (Grand Rapids) site had well-defined upper and lower tiers that

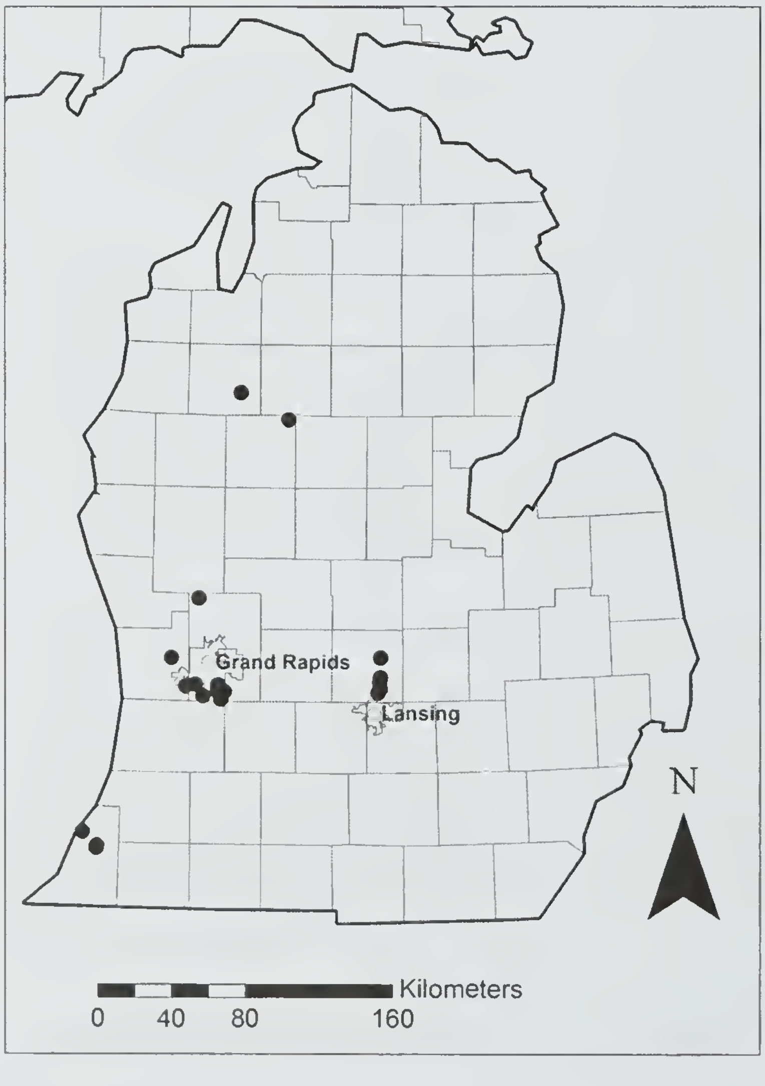

FIGURE 1. Location of wetland mitigation study sites in the state of Michigan, USA. Ten sites were in the greater Grand Rapids region, 5 near Lansing, 4 near Benton Harbor, and 2 near Cadillac.

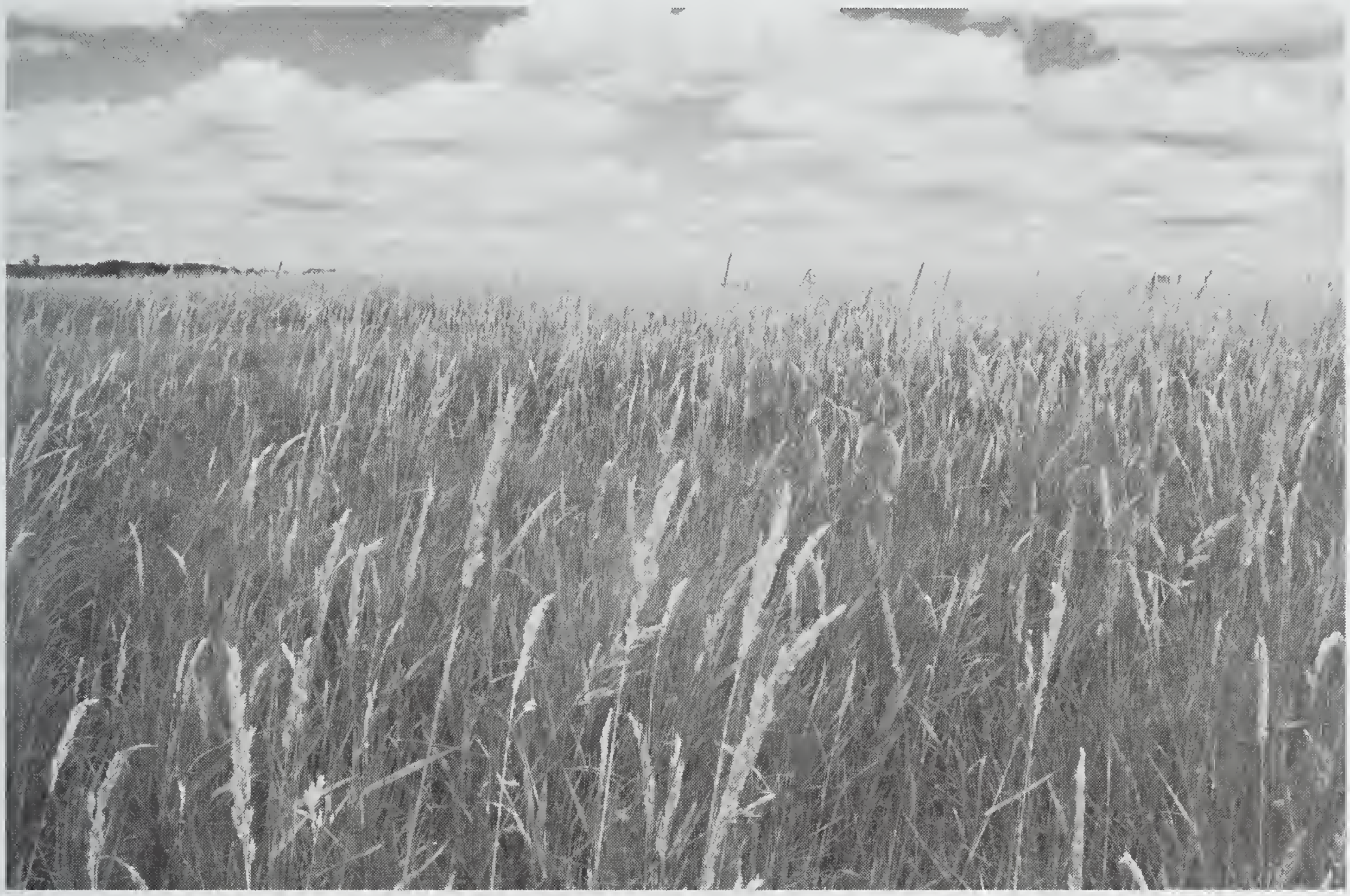

FIGURE 2. The 8 year old wetland mitigation in Manton, MI (Prairie Chicken – 30th Ave. & 22 mile Rd.) was assigned a BPJ quality of 3. It had abundant perennial cover but only 6 native species. Invasive *Phalaris arundinacea* comprised 69% of relative cover, while native *Carex strica* had relative cover of 16%.

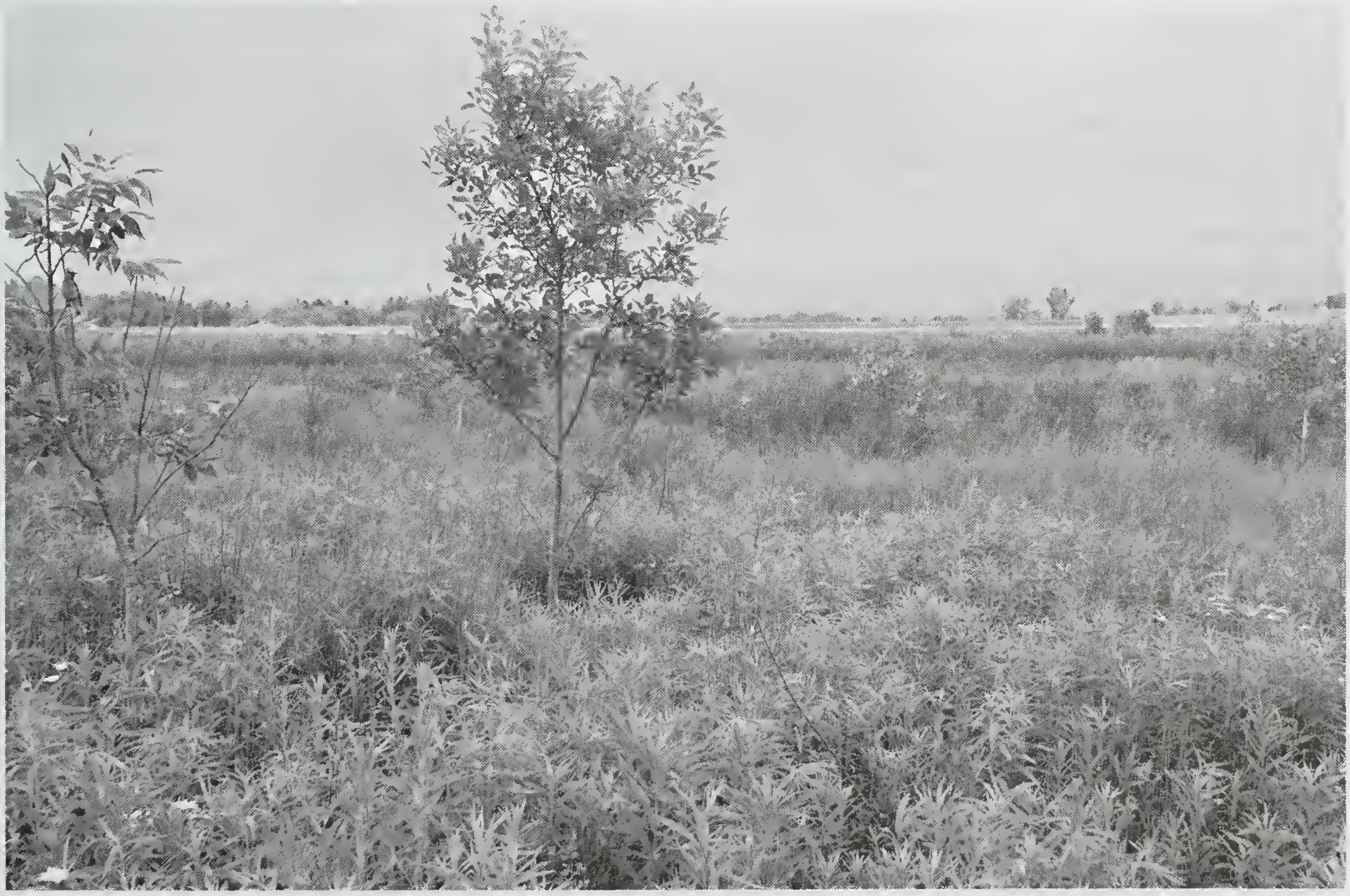

FIGURE 3. The 6 year old Benton Harbor (Parcel 304) mitigation had patchy cover by *Calamagrostis canadensis* and *Juncus effusus* but expanding clones of *Solidago altissima.* It was assigned a BPJ of 5 due to the abundance of non-wetland species, *S. altissima* and, although 20 native wetland species were present, only 2 had high frequency and cover.

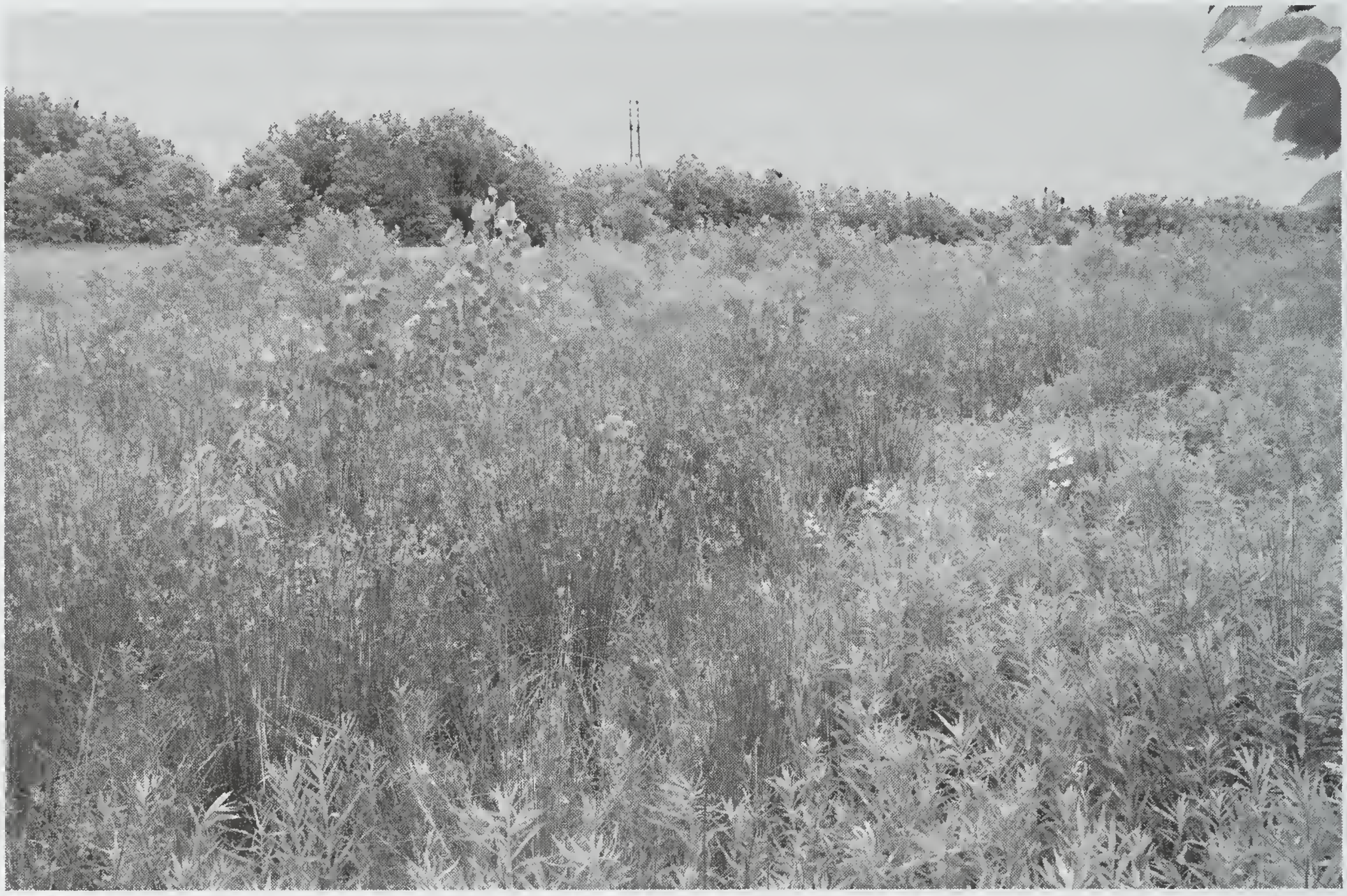

FIGURE 4. Benton Harbor Site 314 (at transition from upland to wetland vegetation) was 6 years old and attained a BPJ quality of 7. The dominate species was the perennial *Juncus effusus* (relative cover = 26%). The native wetland diversity included 9 Cyperaceae species, 4 Poaceae, and 19 forbs. The only non-native or non-wetland species of significance were *Typha* spp. with a combined relative cover of 12%.

were sampled separately. The upper tier was planted with trees such as *Populus deltoides* (eastern cottonwood), *Salix* spp. (willows), and *Quercus bicolor* (swamp white oak). The lower tier, the wetter of the two, was planted primarily with herbaceous wetland plants. Many of the sites had standing water, even in the months of June and July. During this study period (summer 2007), Michigan was under drought conditions in mid June to late July 2007 which was reflected in the low water levels present at many sites. Some sites contained characteristic wetland plants, and often had certain areas that were moist at the surface, but no standing water was present. Several sites, but most notably Lansing I-69, were almost completely dry.

Sampling and Data Analysis

An approximately half-hectare section at each of the sites was strategically selected for sampling. Because of the varying shape and wetness of large mitigation sites, sampling was focused on the area that most strongly exhibited wetland hydrology and vegetation. Prior to actual plot sampling, the site was assigned a value of quality based on the Best Professional Judgment (BPJ). BPJ was used since typical disturbance indices (e.g., Lopez and Fennessy 2002) are designed for estimating quality of natural rather than mitigation wetlands. As a result, mitigation wetlands, with locations near human development and in early successional stage, consistently score poorly. BPJ is a descriptive approach to assessment that relies on ratings or rankings performed by individuals with knowledge of the area and system (USACE 2003). The BPJ approach has proven useful for testing of bioassessment indicators (e.g., Shelton and Blockson 2004, Ranasinghe et al. 2009) and recent work demonstrates its repeatability, especially when experts identify parameters used in making their assessments (Bay et al. 2007, Weisberg et al. 2008, Teixeira et al. 2010).

To guide our assignment of relative quality categories, we devised a BPJ ranking scale (Table 1) based upon USACE (2008, 2009) vegetation performance standards. The BPJ scale had 8 categories with 1 being the lowest quality and 8 being the highest quality. The ranking scale was de-

TABLE 1. Best Professional Judgment (BPJ) visual *a priori* quality ranking scale for wetland mitigations.

Ranking	Metrics
1	Low cover by wetland plants, most cover by invasives
2	Low cover by wetland plants, most cover by native species
3	Vigorous plant cover, mostly invasive or non-wetland species, limited diversity of native wetland plants whether annual or perennial (usually 10 or fewer species)
4	Vigorous wetland plant cover, invasive or non-wetland species prevalent (30-50% aerial cover), >20% cover by annuals or ~10 or fewer perennial species
5	Vigorous wetland plant cover, invasive or non-wetland species somewhat prevalent (15-30% aerial cover), <20% annual cover, ~10–20 native perennial wetland species but only a few dominant ones
6	Vigorous wetland plant cover, low cover by invasive or non-wetland species (<15% aerial cover), few annuals (<10% cover), moderate native diversity (10-25 species)
7	Vigorous wetland plant cover, few invasive or non-wetland species (5–10% aerial cover), few annuals (<10% cover), high native wetland plant diversity (20–35 species), 5 or more species with abundant cover
8	Outstanding mitigation, vigorous perennial cover, almost no invasives (<5%), very high native wetland plant diversity (>30 species) in heterogeneous patches

pendent on the perceived diversity and cover of these plant guilds—non-native, non-wet, annual, and native perennial wetland species (Figures 2–4). Cut-off values were meant to be illustrative since precise measurements were not part of this rapid visual evaluation. BPJ value for a site was based only on the area to be sampled; the quality of the remainder of the mitigation wetland outside of the sampled area was not assessed.

The quantitative sampling used a grid of 49m × 98m for most sites, but at a few sites the grid had a dimension of 42m × 105m due to varying wetland shapes. The grid was sampled using a baseline and transect method. This divided the sample area into 7m × 7m grid plots. Twenty of these grid plots were randomly sampled using both 1.0 m^2 (i.e., 1 × 1 m) and 0.25 m^2 (i.e., 50 × 50 cm) quadrats. The species within each quadrat were identified, and the percent aerial cover occupied by each species was visually estimated and recorded.

Data analysis was performed using the Transect Study option in the *Floristic Quality Assessment Computer Program* Version 1.0 (Wilhelm & Masters 1999). FQA assessments generate the following metrics: mean C value, Floristic Quality Index (FQI), mean wetness, relative frequency, relative coverage, relative importance value, and the total and percentage of native and adventive (non-native) species. The mean C, FQI, and mean wetness are computed with and without adventive species. These same metrics are also computed at the transect level and at the quadrat level. For transect level metrics, mean C and related metrics are based simply upon the inventory or roster of species observed along the transect. For quadrat level analyses, metrics are first calculated for each quadrat independently, then averaged. Thus, in quadrat level analysis, but not in transect level analysis, species frequency is important. Quadrat level averages for mean C and FQI (especially for total species, i.e., native + adventive species) have been shown to be stronger predictors of overall site quality (Taft et al. 2006; McIndoe et al. 2008) and were used throughout this study. The Floristic Quality analyses for each site were computed using both the Michigan as well as the Indiana and Chicago FQA databases.

Statistical analyses were generated using Minitab® Statistical Software. Spearman rank correlations (with BPJ as independent variable) and Pearson correlations were performed to determine correlations between variables. The four main outputs of FQA (mean C value, FQI, mean wetness, and total species) were computed. Mean wetness was included in the study since, even though one might not anticipate it to have a relationship to overall site quality, it does indicate whether or not hydrophytic vegetation is frequent in the sample quadrats. Finally several FQA metrics were compared with three widely used species diversity indices (Simpson's Index (D), Shannon's Index (H'), and Shannon-Wiener Evenness (E)) calculated on the basis of cover values.

RESULTS

The most common species encountered at the 21 sites were *Phalaris arundinacea* (reed canary grass), *Typha angustifolia* (narrow leaf cattail), *Typha latifolia* (broad leaf cattail), *Ludwigia palustris* (water purslane), *Carex* spp. (sedges), *Juncus* spp. (rushes), and *Scirpus* spp. (bulrushes). Most sites with areas of deep water were dominated by *Wolffia columbiana* (common water meal) and *Lemna minor* (small duckweed). Of non-native plants, *Phalaris arundinacea* (Figure 2) and *Typha angustifolia* were the most common, found at nearly every site.

In spite of exotics content, the sites covered a broad spectrum of quality based upon the BPJ scale. The poorest site was assigned a BPJ of 2 while the three most successful mitigation wetlands received a ranking of 7. None of the mitigation wetlands were ranked as a 1 or an 8 on the BPJ scale. Based upon 1.0 m^2 quadrats, the site with the highest species richness (Benton Harbor – Parcel 314) had 34 native species compared to 6 for the most species poor site (Manton). The mean number of species found on the sites was 19.5. The number of species plotted against BPJ yielded a low correlation of $r = 0.26$ ($P = 0.25$) (Figure 5A). As might be expected, slightly fewer native species were encountered when using 0.25 m^2 quadrats. Under this sampling regime, a maximum of 25 species was recorded on the most species-rich site.

Mean C

The mean C (all species including adventives) for the 21 sites (Figure 5B) ranged from 0.8 to 2.9 based upon 1.0 m^2 quadrats and the Michigan FQA database. The BPJ value at the site with the lowest mean C was 2 (Lansing—I-69/US 27); at the site with the highest mean C, the BPJ value was 6.5 (Grand Rapids – M-6). A correlation of mean C versus BPJ yielded a value of $r = 0.83$ ($P \leq 0.000$) (Figure 5B). Mean C in the 0.25 m^2 quadrats across the 21 sites ranged from 0.7 to 3.3 (Michigan database). The BPJ ranking at the site with the lowest mean C was 2; at the site with the highest mean C, it was 6.5.

Based on the mean C values from the Michigan database, the two quadrat sizes (1.0 m^2 and 0.25 m^2) had highly correlated mean C results ($r = 0.95$, $P \leq 0.000$; Figure 6). The r-values were slightly less when using the Indiana and Chicago FQA databases.

FQI

The FQI values for each of the 21 sites (Figure 7A) ranged from 2.0 to 6.1 (based upon native + adventive species; 1.0 m^2 quadrats; Michigan FQA data-

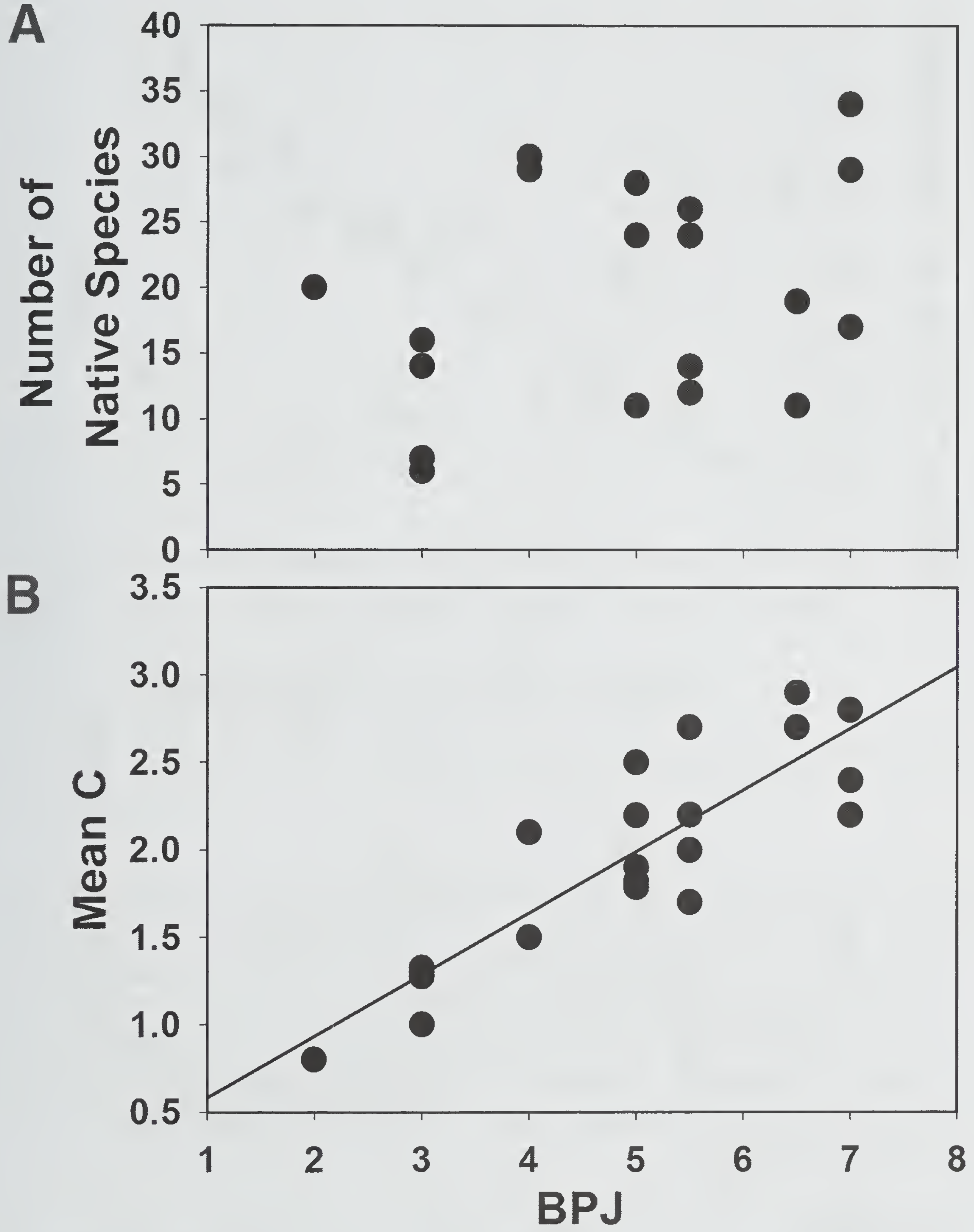

FIGURE 5. Two Floristic Quality metrics compared with Best Professional Judgement (BPJ). A. Number of native species (1.0 m^2 quadrats) versus BPJ; r = 0.26, $p = 0.25$. B. Mean C (1.0 m^2 quadrats) versus BPJ; r = 0.83, $p \leq 0.000$.

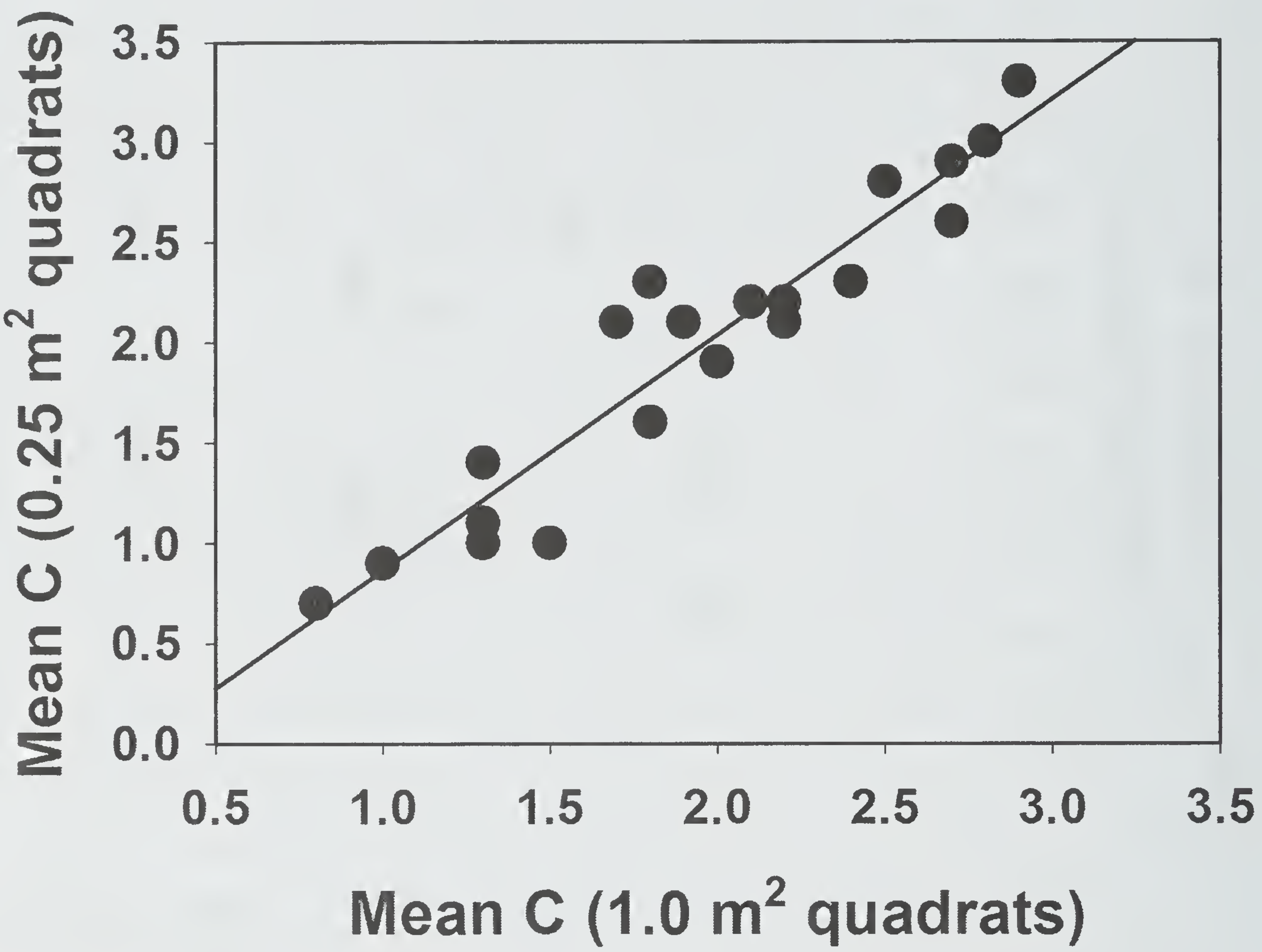

FIGURE 6. Mean C: 1.0 m^2 quadrat versus 0.25 m^2 quadrat; r = 0.95, $p \leq 0.000$.

base). The BPJ value at the site with the lowest FQI value was 2; at the site with the highest FQI, the BPJ value was 7. The correlation between FQI and BPJ yielded an r = 0.70 ($P \leq 0.000$; Figure 7A). The FQI values based upon 0.25 m^2 quadrats were slightly lower, ranging from 1.5–5.6 (Michigan FQA database). The BPJ value at the site with the lowest FQI was 2; at the site with the highest FQI, the BPJ value was 6.5. The Indiana database provided similar FQI values—ranging from 2.2 to 6.1(for 1.0 m^2 quadrats) and from 1.5 to 5.2 (for 0.25 m^2 quadrats).

Mean Wetness

The mean wetness values for each of the 21 sites (Figure 7B) ranged from 0.0 to –4.8 (where –5 = OBL, 0 = FAC, and +5 = UPL). Thus, all sites in the study had areas dominated by wetland plant species. The BPJ value at the driest site was 4.0; at the wettest site, it was 5.5. Mean wetness plotted against BPJ yielded a low correlation (r = –0.27, $P = 0.23$) (Figure 7B). The mean wetness value for 0.25 m^2 quadrats ranged from 0.6 to –4.6 (Michigan FQA database). The BPJ at the driest site was 4; at the wettest site, the BPJ value was 5.5. As expected, the mean wetness values based upon the Indiana database were similar to those of Michigan.

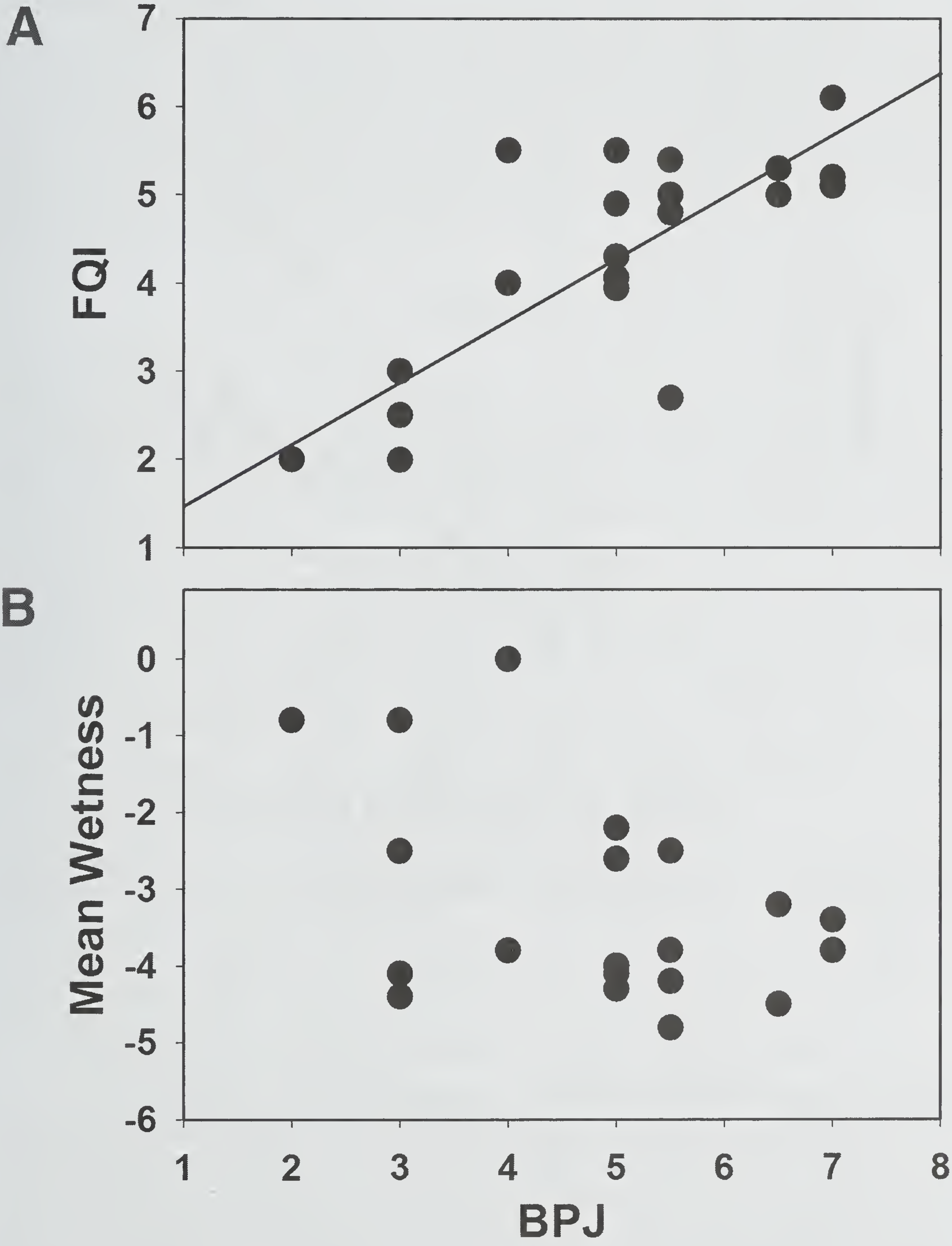

FIGURE 7. Two Floristic Quality metrics compared with Best Professional Judgement (BPJ). A. FQI (1.0 m^2 quadrats) versus BPJ; r = 0.70, $p \le 0.000$. B. Mean wetness (1.0m^2 quadrats) versus BPJ; r = –0.27, $p = 0.23$.

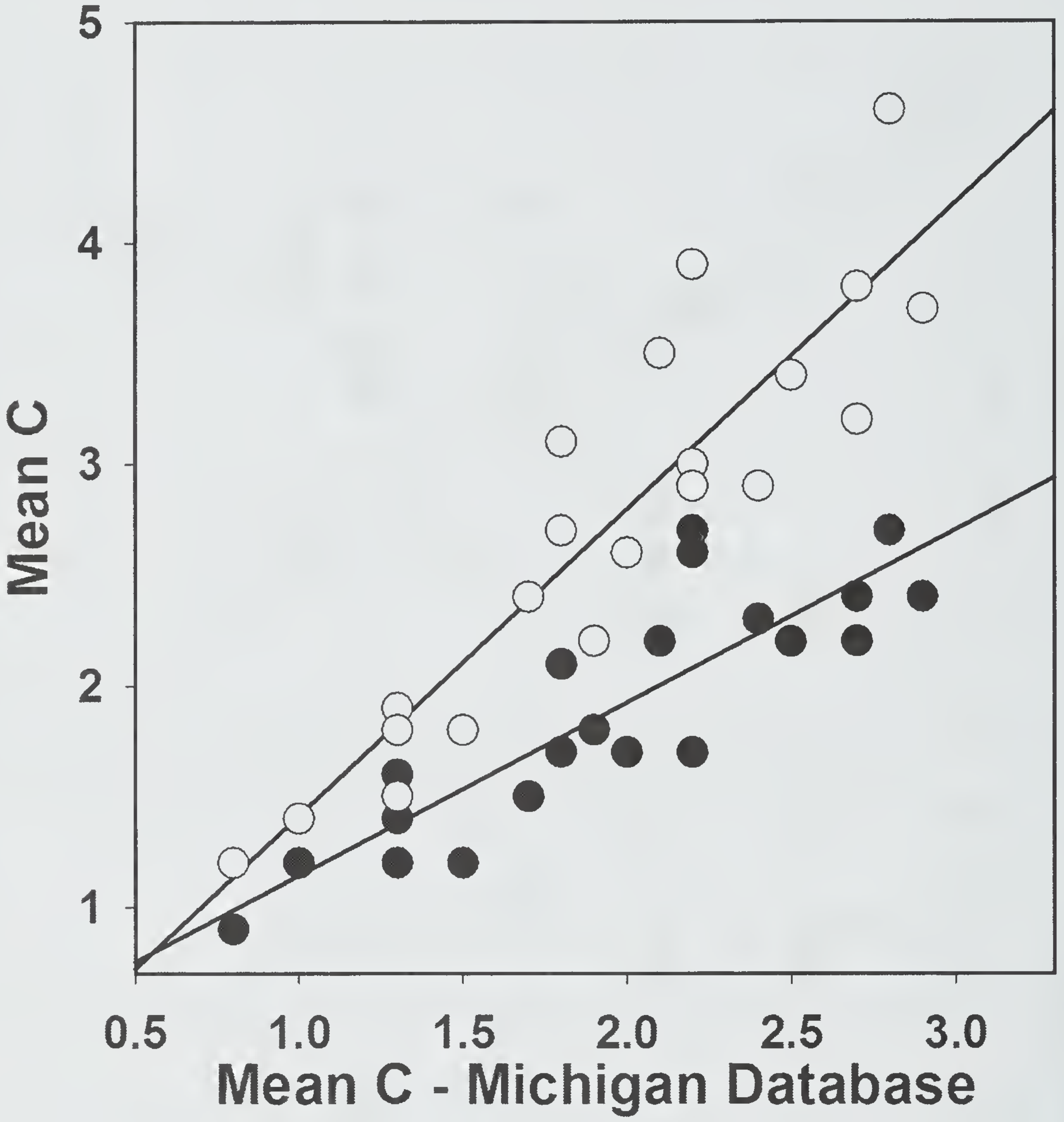

FIGURE 8. Mean C values of Michigan database versus Indiana database (filled circles) and versus Chicago database (open circles); r (Indiana database) = 0.87, $p \leq 0.000$; r (Chicago database) = 0.91, $p \leq 0.000$.

Michigan versus Indiana and Chicago databases

Because FQA databases are tailored for specific regions, it is recommended that one use the database most proximal to the site in question (Swink and Wilhelm 1994). However, since Michigan and Indiana are adjacent states in the same ecoregion (Woods et al. 1998), and the Chicago region includes portions of both northern Indiana and southwestern Michigan, one might expect comparable results from these different databases. The mean C results were used to compare the three databases. The Indiana FQA database versus the Michigan FQA database had a correlation of r = 0.87 ($P \leq 0.000$) (Figure 8). The Indiana database yielded slightly lower mean C compared to the Michigan database for the 1.0 m^2 (Figure 8) as well as 0.25 m^2 quadrats. The Chicago FQA results versus those for Michigan also had a high correlation (r = 0.91, $P = \leq 0.000$). In this case, however, mean C and FQI from the Chicago database were noticeably higher.

Other diversity indices

Several common diversity indices (Simpson's Index, Shannon's Index, and Shannon-Wiener Evenness) were compared to BPJ and to the Michigan mean C and FQI results (1.0 m^2 quadrats). In each case, the r values were less than 0.45. The species evenness index versus mean C had the lowest correlation (r = 0.15), although no mean C correlation exceeded an r = 0.20. FQI, with its species richness component, attained r = 0.44.

DISCUSSION

FQA

FQA can effectively assess the quality of natural wetlands (Ladd 1993, Taft et al. 1997, Francis 2000, Lopez and Fennessy 2002, Bernthal 2003, Matthews 2003, Herman 2005, Bourdaghs et al. 2006, Nichols et al. 2006). Several studies (Elifritz and Fennessy 1999, Mushet et al. 2002, Herman 2005) have tested it for use in wetland mitigations and restorations as well. In our study, FQA proved to be an indicator of wetland mitigation quality based upon strong correlations of mean C and FQI with BPJ. The mean wetness and number of native species, however, do not appear to be indicative of overall site quality; their r-values were extremely low and the *P*-values were not significant.

Although the principal goal of wetland mitigation is to create a wetland that replicates the quality and function of the destroyed wetland (USACE 2008), this does not always occur (Race and Fonseca 1996, Mitsch et al. 1998, Morgan and Roberts 1999, Zedler and Callaway 1999, Ambrose 2000, Brown and Veneman 2001, Sudol and Ambrose 2002, Minkin and Ladd 2003; but see Elifritz and Fennessy 1999, Balcombe et al. 2005). Chicago USACE (2009) lists native mean C of 3.5 or higher and FQI above 25 among its benchmarks for successful mitigation. Given our survey of MDOT mitigations, these expectations are seldom met and may be unrealisitic. In fact, only two of 21 sites had a native mean C above 3.0.

In contrast, the Detroit USACE (2008) success criteria state that mitigation wetlands should attain FQA numbers equal to or exceeding those of the original site. With the exception of highly disturbed natural wetlands that are monocultures of low quality species (e.g., *Phalaris arundinacea* and *Typha angustifolia*), the mean C and FQI values from our mitigation sites were consistently lower than values found in natural Midwestern wetlands. Mean C values in natural wetlands range from approximately 2.7 to as high as 6.2 (Rothrock and Homoya 2005). This coincides with our experience in several wetlands from northern Indiana. A site at Marsh Lake (Steuben County) (unpublished data), which was a disturbed natural site, attained a mean C of 3.1; this was on the high end of the range recorded for mitigation wetlands in this study. Another disturbed site comprised mostly of *Typha* spp. and *Scirpus atrovirens* (dark green bulrush) (Grant County, Indiana) attained a mean C of 2.9. Natural, undisturbed wetlands can have much higher mean C values, such as 4.2 as seen in a natural wetland (Claphan site, *Carex stricta* (tussock sedge) meadow) in

Steuben County, Indiana (unpublished data). Here, high C value species (i.e., C = 8–10) made up nearly 20% of the species total. As an area is degraded or is in the early stages of succession, the plants at the high end of the C value range are less frequent or less likely to persist (Swink and Wilhelm 1994). Mitigation wetlands in the early stage of development are early successional communities that lack the hydrology, soils, and microbial symbionts required by many of the higher C values species (Spyreas et al. 2012). Thus, based upon the low mean C values encountered at our study sites, mitigation wetlands may not be able to fully recapture the vegetative diversity and functional quality of natural wetlands within a short time period.

This study found a strong relationship between FQI and *a priori* BPJ. At the same time, FQI can be difficult to interpret among different studies since the amount of area and intensity of sampling, factors that easily affect outcome, are not consistent among researchers. If FQIs are based upon non-quadrat inventory of a large area with multiple habitats, FQI values frequently range from 27 to 42 in sites of moderate remnant natural value (Swink and Wilhelm 1994; Rothrock and Homoya 2005). This value can be even higher in areas with nature preserve potential. However, these FQI values are not helpful in interpreting mitigation wetlands that consist of one habitat type and are early successional communities, especially FQIs based upon only 20 sample plots. The more useful comparisons are based upon mean FQI per quadrat, i.e., mean FQI per m^2. The mitigation wetlands in our study attained quadrat FQIs ranging from 2.0–6.1. This compares favorably to old fields (Rothrock et al. 2011) and prairie reconstructions (McIndoe et al. 2008) that experienced similar sampling intensity. At the same time, the FQI values for these mitigation sites are lower than those of a disturbed natural wetland (Marsh Lake site) and a natural, undisturbed wetland (Claphan site) where quadrat FQI = 6.8 and 9.9, respectively (unpublished data).

There are currently few published reports on the performance of FQA in wetland mitigations (Elifritz and Fennessy 1999, Balcombe et al. 2005, Herman 2005). Nonetheless, we believe that the results obtained from the mitigation wetlands in our study may be typical. For comparison we obtained unpublished data from 10 mitigation sites in northern Indiana that were assessed by Cardno JFNew, an ecological services company located in northern Indiana. Based upon FQA transect studies, mean C in these mitigations ranged from 0.4 to 3.7, and FQI values ranged from 1.0 to 11.8. Both the mean C and FQI (Michigan database) from our sites fall into about the same range. The Cardno JFNew values were obtained using the Chicago database, which tends to produce slightly inflated C values when compared to the Michigan database. These sites also contained less *Phalaris arundinacea* and *Typha angustifolia* than were present in the Michigan sites. These factors could both contribute to the slightly higher FQA results.

1.0 versus 0.25 m² quadrats

The correlation of mean C between 1.0 m^2 quadrats and 0.25 m^2 quadrats was high, r = 0.95 ($p \leq 0.000$), a result supported by Bever (2006). Increasingly, observers prefer the 1.0 m^2 quadrat (Bourdaghs et al. 2006) over the

0.25 m^2 quadrat (Morgan and Roberts 1999) since it may more effectively sample species richness. One concern in using a 1.0 m^2 quadrat as opposed to a 0.25 m^2 quadrat is that it may be more difficult to estimate species cover values when examining a larger area. In our experience, however, the amount of time required per 1.0 m^2 quadrat versus a 0.25 m^2 quadrat did not differ considerably. USACE Detroit District does not recommend one quadrat method over the other, as long as the responsible party clearly describes the quadrat size used (USACE 2008); the Chicago District requests that 1.0 m^2 quadrats be employed (USACE 2009).

Michigan versus Indiana and Chicago databases

Another objective of this study was to compare results based upon the Michigan FQA database versus the Indiana FQA and Chicago FQA databases. The comparison of these databases informs whether the range of data obtained in Michigan may be generalized to other regions.

In our analysis, the three databases did produce comparable results. In most mitigation wetlands, the species present are tolerant, early to mid-successional species that have lower C values. Because of their clear and familiar ecological behavior, the various local databases tend to assign them the same or very similar C values (Rothrock and Homoya 2005). Furthermore, Michigan and Indiana are adjacent states (with the Chicago database including portions of both states) and in the same ecoregion (the Southern Michigan/Northern Indiana Drift Plains) (Woods et al. 1998) which further leads to the expectation that similar C values have been assigned.

At the same time, the Chicago results tended to be higher and the Indiana results somewhat lower than those of Michigan, with the differences becoming more apparent as the overall quality of the site increased. This may be because the species present at the higher quality sites are more habitat-specific or have ecological variations across ecoregions (e.g., *Thuja occidentalis* in Michigan (Herman et al., 2001)), which might lead to fluctuations in C values by region. This also could make species in the mid-range values of conservatism more difficult for independent, regional panels of botanists to consistently assign to a C category (Rothrock and Homoya 2005, Bourdaghs et al. 2006). Nonetheless, the high correlation between the Michigan FQA database versus the Indiana FQA and Chicago FQA databases shows that each can give comparative, useful results. This knowledge might be especially helpful for sites located on or near the border between two states. If one is concerned about the modest differences in FQA metrics, then the state in which most of the sites are located should determine the database to be used. Alternatively one could create C values specifically for that area by using the average of the C values from both states (Bourdaghs et al. 2006, Spyreas et al. 2012). This particular method was used in the assessment of coastal wetland sites near the Michigan/Wisconsin border.

Related ecological indices

A final aspect of this study was to compare several ecological indices with FQA to determine if a correlation existed between them and whether these indices also provide complimentary descriptions of wetland mitigation quality. The indices used in the comparison were Simpson's Diversity Index (D), Shannon's Diversity Index (H'), and Shannon-Wiener Evenness (E). The results showed that all three had low correlations compared with the mean C, FQI, and BPJ. In this study, these indices did not quantify wetland quality or at least the same aspect of quality.

The lack of correlation between FQA metrics and ecological indices (especially H′ and E) could be expected (Taft et al. 2006). The three ecological indices measure either species diversity and/or, to a greater extent, evenness (Magurran 2004; Peet 1974; Squiers and Wistendahl 1977). All three treat each species as ecologically equivalent to another. Thus, the presence of common non-native species "improves" species diversity (Lamb et al. 2009). In contrast, mean C is based upon a species fidelity concept (Swink and Wilhelm 1994). FQI does include species richness but is devoid of any measure of species evenness. Nonetheless, the apparent lack of sensitivity of these ecological indices in measuring quality in our mitigation sites remains somewhat puzzling. H′ and E proved efficacious in analyzing floristic integrity (Ulanowicz 2000) in prairies and prairie restorations, though not as effectively as FQA (Taft et al. 2006). Several multimetric indices (Nichols et al. 2000, Simon et al. 2001) employ a Diversity Index with apparent success in aquatic ecosystems. Diversity indices may provide useful information on changes occurring within a mitigation wetland over time but, at the least, are difficult to interpret (Lamb et al. 2009).

Of the three ecological indices, Simpson's Diversity Index is generally considered the most meaningful and robust measure of diversity (Margurran 2004). Calculated values for Simpson's Index fall between 0 and 1, with values closer to 0 representing higher diversity (Squiers and Wistendahl 1977). With the exception of one wetland mitigation site (Manton – Prairie Chicken had a $D = 0.55$), the index values ranged from 0.07 to 0.36. This equates with high diversity. The MDOT wetland mitigations in this study were sown with diverse seed mixes and, as a result, most supported 20–30 native species. As expected, the site (at Manton) with the highest Simpson's Index had a mere 6 species. Calculated values of Simpson's Index in these wetland mitigation sites likewise were influenced by the eveness or heterogeneity of species cover. Typically these MDOT wetland mitigation sites had only 3 species with high cover. The remaining species had more or less uniformly low cover with means that seldom exceeded 15% per quadrat.

Vegetation and floristic integrity (Ulanowicz 2000) is only one aspect of wetland ecological function; it does not address other wetland functions such as soil, hydrology, and landscape setting. Nonetheless, our analysis indicates that FQA, especially quadrat averages for mean C and FQI, provides an effective quantification of some mitigation wetland functions and provide ecosystem information not measured by Diversity Indices. With appropriate care in interpretation, these metrics can be robust across different FQA databases and with variations in sampling protocol such as quadrat size.

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APPENDIX 1. State of Michigan wetland mitigation sites used in this study. BPJ = best professional judgement (see Table 1), MC = mean C, NSR = number of native species, FQI = Floristic Quality Index. MC, FQI, and MW are based upon all species, native plus adventives; NSR represents a transect total; other FQA values are averages per m^2.

Location	Latitude and Longitude	Age at Time of Sampling	Size (ha.)	BPJ	MC	NSR	FQI	MW
Benton Harbor— Klock Rd.	N42° 7.322′ W86° 28.066′	5	1.6	5	1.8	11	4	–4.1
Benton Harbor— Naomi	N42° 2.675′ W86° 22.623′	7	10.1	3	1.3	14	3	–0.8
Benton Harbor— Parcel 304	N42° 2.853′ W86° 22.573′	6	5.7	5	2.2	28	4.9	–2.6
Benton Harbor— Parcel 314	N42° 3.426′ W86° 22.383′	6	2.8	7	2.2	34	5.1	–3.8
Cadillac— Boon Rd.	N44° 16.776′ W85° 27.947′	7	2.4	7	2.8	17	6.1	–3.8
Grand Rapids— 92nd St. SW	N42° 47.897′ W85° 41.575′	4	16.2	6.5	2.7	11	5.3	–4.5
Grand Rapids— 100th St.	N42° 46.945′ W85° 34.408′	3	6.9	5	1.8	11	4.0	–4.0
Grand Rapids— Bailey Bridge	N43° 16.384′ W85° 43.848′	7	2.0	7	2.4	29	5.2	–3.4
Grand Rapids— Ivanrest	N42° 51.205′ W85° 44.634′	6	10.1	4	2.1	29	5.5	–3.8
Grand Rapids— M-6 (8th Ave.)	N42° 50.663′ W85° 48.450′	4	3.2	6.5	2.9	19	5.0	–3.2
Grand Rapids— M-37 (Patterson)	N42° 49.297′ W85 ° 33.064′	10	5.3	5.5	2.0	26	5.0	–2.5
Grand Rapids— M-45 (Blueberry Farm)	N42° 58.921′ W85° 54.428′	6	8.1	5.5	1.7	12	2.7	–3.8
Grand Rapids— Warner	N42° 49.345′ W85° 35.880′	6	21.0	5	1.9	24	4.3	–2.2
Grand Rapids— Weaver (lower)	N42° 51.139′ W85° 35.404′	7	4.5	5.5	2.2	24	4.8	–4.2
Grand Rapids— Weaver (upper)	N42° 51.154′ W85° 35.631′	7	6.1	5	2.5	28	5.5	–4.3

Continued

APPENDIX 1. Continued.

Location	Latitude and Longitude	Age at Time of Sampling	Size (ha.)	BPJ	MC	NSR	FQI	MW
Lansing—I-69 near US 27 business	N42° 49.158′ W84° 31.862′	10	5.7	2	0.8	20	2.0	–0.8
Lansing—Parcel 528	N42° 59.584′ W84° 30.981′	12	11.3	3	1.3	7	2.5	–4.4
Lansing—Sears-Rouse	N42° 52.302′ W84° 31.293′	8	14.6	4	1.5	30	4.0	0
Lansing—US 127 (Alward Rd, Boron)	N42° 53.646′ W84° 30.892′	8	8.1	3	1.0	16	2.0	–2.5
Lansing—US 127 (E. Howe Rd., Lerg)	N42° 50.304′ W84° 31.005′	7	3.6	5.5	2.7	14	5.4	–4.8
Manton—Prairie Chicken (30th Ave. & 22 mile Rd.)	N44° 8.960′ W85° 8.428′	8	10.5	3	1.3	6	2.0	–4.1

NOTEWORTHY COLLECTIONS

MICHIGAN

Ilex opaca: *Aquifoliaceae* (American Holly)

Previous knowledge. American holly (*Ilex opaca* Aiton) is a perennial, evergreen, dioecious shrub or tree in the Aquifoliaceae. It is native to the east coast from Massachusetts to Delaware and then inland in coastal states south to the middle of Florida and west to Texas and southeastern Oklahoma, reaching inland as far north as West Virginia, Kentucky and Missouri (Grelen 1990). In addition, the USDA Plant Database (USDA, NRCS 2002) has it in Maine, extreme southern Illinois and central and southern Ohio. Overlease and Overlease (2007) list it from the southern third of Indiana, reproducing from introduced ornamental plantings. In La Porte County, they recorded several mature trees, but no seedlings or saplings (Overlease and Overlease 2007). Neither Voss (1985) nor Swink and Wilhelm (1994) lists American holly from Michigan.

In Pennsylvania, American holly is listed as a threatened species and in New York as “exploitably vulnerable” (USDA, NRCS 2002).

Significance of the report. We report the first occurrence of American holly in Michigan, specifically in Allegan and Berrien counties. *I. opaca* (Figure 1) was first found in 2002 at two sites on old beach sands from post-glacial lake beds near Saugatuck. At these locations, which are about 3 km apart, numerous small, vegetative trees were growing in shaded, sandy soil in a southern mesic forest and an overgrown mixed pine plantation. In 2009, at the Berrien County locale, which is about 100 km south of the Allegan County sites, we found three small, vegetative individuals growing about 30 meters apart in a sandy, second growth, southern mesic forest at Tower Hill Retreat and Camp north of Sawyer. The Berrien County site is about 30–50 km north of the La Porte County site reported by Overlease and Overlease (2007). In 2010, three more small American holly plants were found in an old white pine plantation in St. Joseph. This site is about 20 km NNE of the 2009 Berrien County site.

At all of the locales described herein, the American holly plants are probably escapes from cultivation. Our locales are about 400 km from the nearest naturally occurring populations, a distance that seems too great for non-human seed transport. Because birds and/or mammals are known to disseminate the seeds of American holly (Daubenmire 1990; Engstrom et al. 1984), some of these animals may have transported fruits and/or seeds to the woods nearby from some cultivated parents. In Allegan County, one of us (W.M.) found two mature trees across the road from one collection site and about 3 km from the other (Figure 2). The trees, a male and a female, had been planted adjacent to a home. We hypothesize that birds consumed the fruits from the female tree and then defecated the seeds at the collection sites. We also suspect that in Berrien County mature trees (both male and female and growing in close proximity to each other) also

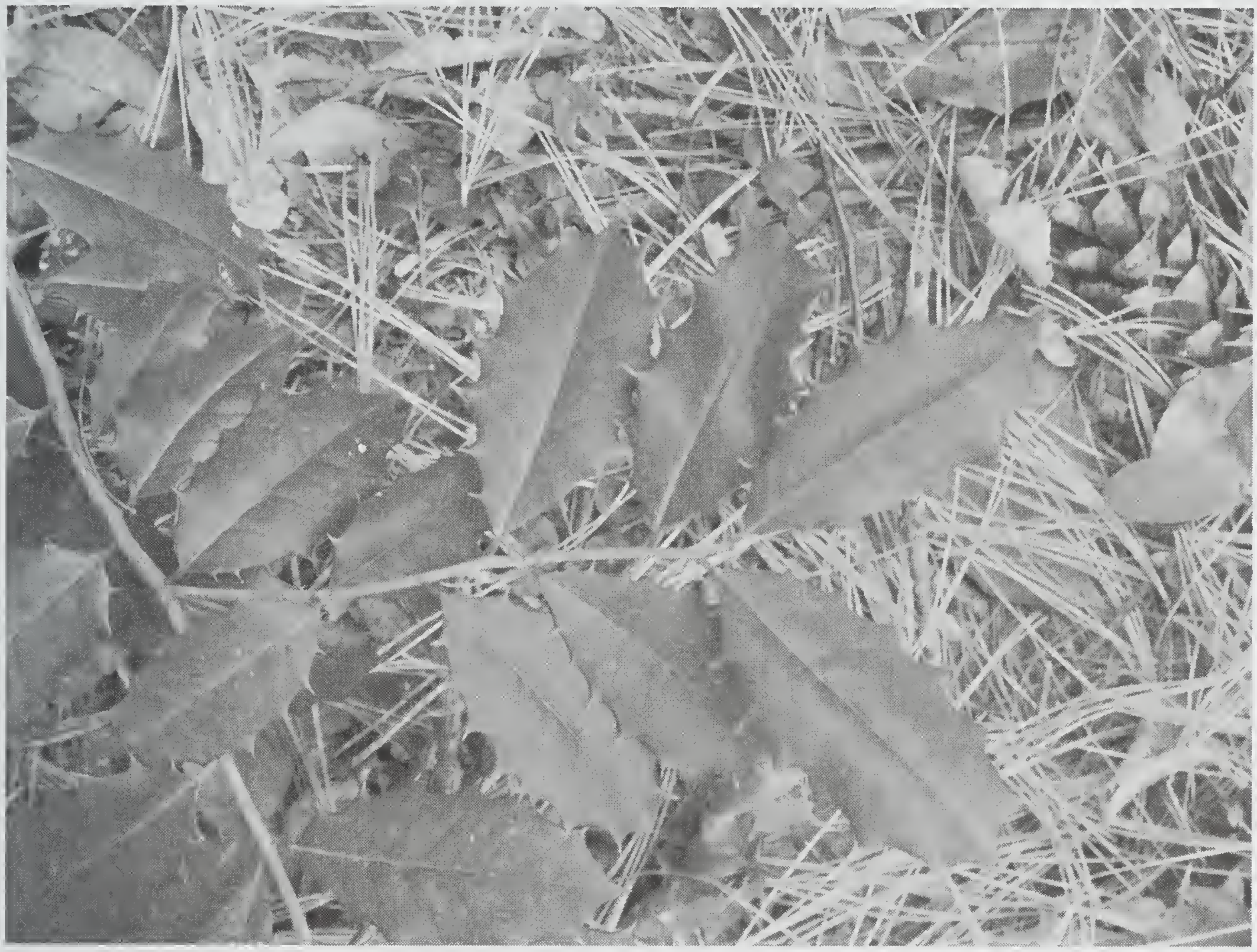

FIGURE 1. *Ilex opaca* leaves.

exist in the vicinity, but have not yet been located. The shaded sandy soil at all sites coincides with soils reported in the preferred habitats for American holly (Grelen 1990). American holly is viable in southwestern Michigan and may appear spontaneously elsewhere in the state.

Specimen citations: Herbarium label information is as follows:

> *Ilex opaca* Aiton. Allegan Co.: 4 mi N of Saugatuck. In opening under wires. Tree 2½ m tall. Dozen more plants within ¼ mi. in hardwoods and pine plantation. Sandy soil along pre Lake Michigan beach. William S. Martinus 354. June 17, 2002. (A voucher has been sent to MICH.)
>
> *Ilex opaca* Aiton. Allegan Co.: 3 mi NE of Saugatuck. Tree 3m tall; 1½" dbh at 4½'. 20 plants within ¼mi. Young woods/old field with some mature hardwoods. Sandy soil along pre Lake Michigan beach. William S. Martinus 355 June 17, 2002. (A voucher has been sent to MICH.)
>
> *Ilex opaca* Aiton. MICHIGAN, Berrien County, about 1 mi N of Sawyer. Along and 1 m from a hiking trail in partial shade at edge of opening in woods. All nearby trees are *Pinus strobus*. Understory associates include *Maianthemum canadense*, and seedlings of *Acer rubrum, Sassafras albidum, Quercus rubra* and *Prunus serotina*. Soil sandy and covered by pine and oak leaves. One plant about 2 dm tall with 5 branches. Elev. 202'.

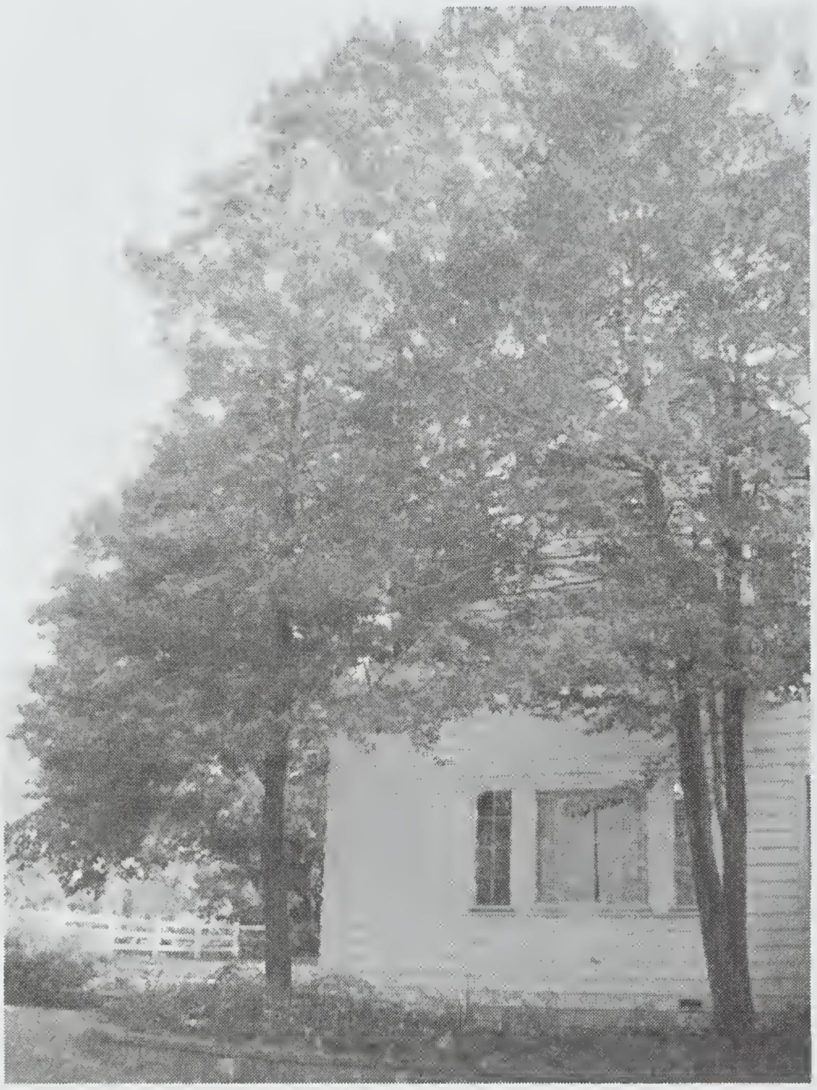

FIGURE 2. Planted *Ilex opaca* trees. One is a male and the other a female. These are thought to be the parents of the trees reported in Allegan County.

21 August 2009. Robert Tatina 4293. (A voucher of this specimen has been sent to MICH and MOR.)

Ilex opaca Aiton. Michigan, Berrien County, St. Joseph Township, Knauf Park, 42° 3′41.57″N, 86°28′56.68″W. North of park entrance at Veineland Road between Lincoln & Washington. Upland of sandy loam overlooking small stream in old white pine plantation with *Pinus strobus*, *Quercus* sp. and *Celastrus orbiculatus*. Only 2 or 3 small plants, none taller than 1.5 m. 14 March 2010. William V. Luitje 11. (A voucher specimen is housed at MICH.)

Ilex opaca Aiton. Ottawa Co.: Palomita Reserve. Ca. 200′ E of Lakeshore Dr. and 300′ S of Pigeon River. T7N R16W, NW ¼ Sect 28. Lat. & Long. 42° 57′ 42.0″N, 86° 12′ 57.6″ W. Single shrubby plant, 1 meter tall, in mid-successional oak/maple woods. William S. Martinus 397. December 23, 2010. (A voucher is deposited at MICH).

Diagnostic characteristics. Gleason and Cronquist (1991) list 9 species of Ilex as native to the USA. Only four of these (*I. opaca, I. vomitoria, I. glabra* and *I. coriacea*) have coriaceous, evergreen leaves. Vegetatively, *I. opaca* may be distinguished from *I. vomitoria* because *I. opaca* has spine tipped leaf margins which *I. vomitoria* lacks. The undersurface of the leaves on *I. opaca* lack punctations which *I. glabra* and *I. coriacea* have.

ACKNOWLEDGEMENTS

We thank Anton Reznicek for alerting us to the Luitje collection and for verifying the identity of all specimens.

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BOOK REVIEW

Wild, Anthony. *Coffee: A Dark History*. W. W. Norton & Company, London, New York. 2005. 344 pp. ISBN-10 0393337391, Hardcover $26.00. Paper $21.95.

Luttinger, Nina, and Gregory Dicum. *The Coffee Book*. The New Press, London, New York. 2006. 224 pp. ISBN-10 1595580603. Paper $16.95.

"The world drinks about 1.5 billion cups of coffee per day—the United States alone drinks one-fifth of this" (Luttinger ix). Where does this coffee come from? What is its history? There are two different, recent books that talk about the history of coffee. The first, *Coffee: A Dark History* is just that, a dark look. When the author set out to write this book, he wanted to focus on the dark side of coffee. He wanted to point out all the unknown difficulties that have arisen from coffee production over the years. Some of these difficulties (the dark side) include various people who have been negatively affected by coffee: either through slavery or growers who have lost their only source of income due to insufficient grower protection during price gouging. Readers should be aware that this book is the author's undocumented ramblings. It does not contain any figures, graphs or citations. In fact, the author purposely did not cite any information, and therefore, the information is not verifiable. For anyone who is interested in this book I would suggest picking it up at your local library first in order to preview it before purchasing.

On the other end of the spectrum, we have the second edition of *The Coffee Book*. The authors decided that American society and its view of coffee had changed so much from the first edition, published in 1999, that they needed to bring out a new edition. In this reviewer's opinion this book is a "must read" for the serious coffee drinker. Not only is the book well written, it is also full of verifiable facts and figures, which make it not only an interesting read, but also an easy read. The figures and facts help bring the story of coffee to life. One of the interesting things the authors do is focus not only on the history of coffee, but also how it has shaped society over the years and today. For example, throughout the book the authors discuss how coffee has moved from the elite drink of the past to something that can be found in almost every household in the United States. The authors also discuss how coffee houses were started and their effect on society over the years. Finally, the authors discuss how the quality of the coffee bean has declined over the years and how coffee farmers from all over the world are being affected by this change. This book is a good overview that is filled with enough detail so that the reader won't feel bogged down with too many facts.

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On the cover: *Tanacetum bipinnatum* in Grand Sable Dunes,
Pictured Rocks National Lakeshore, Alger County, MI.
Photo taken by Jordan M. Marshall July 28, 2011